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AN OPERATIONAL UTILITY ASSESSMENT: MEASURING THE EFFECTIVENESS OF THE EXPERIMENTAL FORWARD OPERATING BASE PROGRAM

By: Earl J. Demersseman, Andrew D. Mack, and Michael A. Witherill

June 2014

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This MBA project conducts a comparative analysis of the Experimental Forward Operating Base (ExFOB) accelerated acquisition process created in 2009 to address the Marine Corps' reliance on liquid fuel for expeditionary operations. This project examines the effectiveness of the ExFOB process in comparison with other acquisition processes to evaluate the ExFOB effectiveness toward reducing expeditionary energy use, and to identify the ExFOB's value added to the Marine Corps.

The findings of this study show that by accelerating selection, test, and evaluation processes, ExFOB has reduced the acquisition time of four energy-saving technologies, generating savings of approximately one year off of the two-year commercial off-the-shelf process. The fuel saved by ExFOB's accelerated process and the capabilities ExFOB has evaluated have the potential to reduce expeditionary energy use by approximately 26 percent by 2016 and keep the Marine Corps on track to meet its 2025 goal. These improvements to the acquisition timeline and expeditionary capabilities of the Marine Corps, coupled with the value added, demonstrate that the ExFOB is instrumental in helping the Marine Corps improve its ability to conduct operations from the sea.

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AN OPERATIONAL UTILITY ASSESSMENT: MEASURING THE EFFECTIVENESS OF THE EXPERIMENTAL FORWARD OPERATING BASE PROGRAM

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LIST OF ACRONYMS AND ABBREVIATIONS

AoA	analysis of alternatives
BES	budget estimate submission
CBA	capabilities-based assessment
CDD	capability development document
CDRT	capabilities development for rapid transition
CPD	capability production development
CJCS	Chairman of the Joint Chiefs of Staff
CMC	Commandant of the Marine Corps
CONOPS	concept of operations
COTS	commercial off-the-shelf
DAS	Defense Acquisition System
DC CD&I	Deputy Commandant for Combat Development and Integration
DOD	Department of Defense
DOTMLPF	doctrine, organization, training, materiel, leadership, personnel, facilities
DPG	Defense Planning Guidance
DT&E	developmental test and evaluation
E2O	Expeditionary Energy Office
EIPT	Executive Integrated Planning Team
EMD	engineering and manufacturing development
ExFOB	Experimental Forward Operating Base
FOB	forward operating base
FYDP	Future Years Defense Program
GREENS	Ground Renewable Expeditionary Energy Network System
HADR	humanitarian assistance and disaster relief
HQ	headquarters
ICD	initial capabilities document
ICW	in conjunction with
IOC	initial operating capability
IT	information technology

JCD	joint capabilities document
JCIDS	Joint Capabilities Integration and Development System
JROC	Joint Requirements Oversight Council
JSD	joint staffing designator
JUON	joint urgent operational need
LED	light emitting diode
LRIP	low rate initial production
MAGTF	Marine Air-Ground Task Force
MEB-A	Marine Expeditionary Brigade-Afghanistan
MCWL	Marine Corps Warfighting Laboratory
MDA	milestone decision authority
MROC	Marine Requirements Oversight Council
NDI	non-developmental item
OEF	Operation Enduring Freedom
OIF	Operation Iraqi Freedom
OT&E	Operational Test and Evaluation
POM	program objective memorandum
POR	program of record
PPBE	plan, program, budget, and execution
R&D	research and development
REF	rapid equipping force
RDT&E	research, development, test, and Evaluation
SPACES	Solar Portable Alternative Communications Energy System
TMRR	technology maturation and risk reduction
UON	urgent operational need
USMC	Unites States Marine Corps
UNP	urgent needs process
UNS	universal needs statement
UUNS	urgent universal needs statement

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I. INTRODUCTION

A. RESEARCH

The Experimental Forward Operating Base (ExFOB) Program was created in 2009 to address the Marine Corps' increasing reliance on liquid fuel for expeditionary operations and the vulnerability to sustained operations created by fuel dependence. Using a small budget, the ExFOB program provides a means to rapidly evaluate and procure commercially available products in order to address a list of identified Marine Corps capability gaps. The goal of this project is to conduct a comparative analysis of the ExFOB process with other acquisition processes, measure the effectiveness of the ExFOB process and products toward reducing energy use, and evaluate the value added to the Marine Corps. To assess the ExFOB's contribution toward a 50 percent reduction in Marine Corps expeditionary energy consumption, this project answers the following three questions:

1. What are the advantages and disadvantages of utilizing the ExFOB program within different acquisition processes?

2. What are the contributions of the ExFOB programs and process?

3. Is the ExFOB value added to the United States Marine Corps (USMC)?

Answering these three questions provides a well-rounded view of the ExFOB, allows an accurate evaluation of the program, and enables recommendations to further improve its effectiveness.

B. BACKGROUND

Throughout 10 years of war in Iraq and Afghanistan, the USMC has continually improved the way it maneuvers and fights against an evolving threat. Many of the improvements include new equipment designed to better protect the Marines and improve their ability to communicate on the move. Compared to the equipment allotment for a Marine Air-Ground Task Force (MAGTF) at the beginning of Operation Iraqi Freedom

(OIF) and Operation Enduring Freedom (OEF), the current allotment includes 250 percent more radios, 300 percent more information technology (IT) and computers, a 200 percent increase in the number of vehicles, a 75 percent + increase in vehicle weight, and a 30 percent decrease in miles per gallon across the tactical vehicle fleet (U.S. Marine Corps Headquarters [USMC HQ], 2011, p. 8). With the exception of the reduced vehicle efficiency, these improvements to the MAGTF have resulted in a more effective force and less risk to the Marines carrying out their missions. Unfortunately, these same improvements have left the Marines more dependent than ever on a reliable supply of energy, mostly in the form of the liquid fuels required to power generators and vehicles. This dependence on energy prompted the Commandant of the Marine Corps (CMC) to declare in 2009 that efficient energy use is a top priority for the USMC. Later that year, the CMC established the Expeditionary Energy Office (E2O), whose task is to create a strategy for the Marines to address their increasing reliance on energy and to minimize the vulnerable logistics trail required to provide that energy.

C. APPROACH

Specifically, this project provides an examination of the contribution of the ExFOB program toward the USMC goal of reducing expeditionary energy consumption by 50 percent by 2025. We examine the USMC E2O, the ExFOB, the urgent universal needs statement (UUNS) process, and the U.S. Army Rapid Equipping Force (REF) in order to gain an understanding of how the USMC and the Army conduct accelerated acquisition to respond to capability gaps as they are identified by warfighters. In addition, the project examines the ExFOB in comparison with traditional acquisition procedures specifically utilized by three processes—the Department of Defense (DOD) 5000-series Defense Acquisition System (DAS), the Planning, Programming, Budgeting, and Execution (PPBE) process, and the Joint Capabilities Integration and Development System (JCIDS). This part of the project examines the results of combining these three processes into an integrated acquisition system. We then compare the acquisition timelines of the DAS, REF, UUNS and ExFOB processes. These comparisons enable us to analyze the performance of the ExFOB program itself as well as the capabilities the

ExFOB has selected, and to assess the value of the ExFOB program toward increasing the operational capabilities of the USMC and reaching the CMC's 2025 energy reduction goals.

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II. BACKGROUND

In seeking to answer the research questions, this chapter categorizes the background information into five sections. The first section is an overview of USMC expeditionary energy strategy and goals, which helps frame the USMC's approach and establishes measures of effectiveness for E2O and the ExFOB. The second section is an in-depth look at traditional acquisition and its components. This section also details how the USMC determined and documented expeditionary energy capability gaps which are the premise for the ExFOB. The next two sections detail ExFOB and REF processes which are compared in the analysis. The last section is an overview of the USMC rapid acquisition process. Understanding all aspects of the various processes and their differences as well as measures of effectiveness are important to the overall analysis.

A. USMC EXPEDITIONARY ENERGY STRATEGY

Energy has been a DOD topic of concern for many years but has not received much attention because of the wars in Afghanistan and Iraq. In 2009, however, the USMC made energy a top priority, so development of a long-range strategy and plan commenced (U.S. Marine Corps Energy Summit 2009 as cited in USMC HQ, 2011). This section draws heavily from *United States Marine Corps Expeditionary Energy Strategy and Implementation Plan* (USMC HQ, 2011). As a key part of the plan, the USMC also established the E2O in late 2009 (Office of the Assistant Commandant of the Marine Corps, 2009). The E2O is the lead proponent for the USMC; the CMC specifically chartered the E2O to "analyze, develop, and direct the Marine Corps' energy strategy in order to optimize expeditionary capabilities across all warfighting functions" (USMC HQ, 2011, p. 5). The USMC strategy's ultimate goal is to provide guidance for reducing the USMC's reliance on fossil fuels in an expeditionary environment. Generally, this aligns the USMC with the DOD energy strategy and goals.

The USMC, as well as other armed forces, has relied heavily on fossil fuels in both Iraq and Afghanistan. In 2010, a report estimated that the USMC used more than

200,000 gallons of fossil fuels per day and over 30,000 gallons per day at forward operating bases (FOBs) in Afghanistan alone. The reality is that the consumption has increased over time because capabilities have increased. Additionally, the energy needs in these austere environments are extremely high and logistically very difficult to support. The cost for liquids such as fuel and water in Afghanistan is also important to consider. The fully burdened cost includes, at a minimum, the following: fuel price, movement, protection, injuries and lives lost. Fuel has been, and always will be, a limiting factor for operations and can sometimes be a constraint; consequently, energy requirements will always be a concern for the USMC. The more the USMC can do to reduce its reliance on fuel, the more flexibility it will have to operate across the full spectrum of military operations.

1. USMC Expeditionary Energy Goals

As stated in the United States Marine Corps Expeditionary Energy Strategy and Implementation Plan,

> By 2025 we will deploy Marine Expeditionary Forces that can maneuver from the sea and sustain its C4I and life support systems in place; the only liquid fuel needed will be for mobility systems, which will be more energy efficient than systems are today. (USMC HQ, 2011, p. 17)

The USMC has numerous energy goals that encompass all aspects of its operations (see Table 1).

<table>
<tr><th rowspan="2">E2 Goals</th><th colspan="3">Efficiency Gains</th></tr>
<tr><th>2015</th><th>2020</th><th>2025</th></tr>
<tr><td>Embed E2 Into USMC Ethos</td><td rowspan="4">25%</td><td rowspan="4">40%</td><td rowspan="4">50%</td></tr>
<tr><td>Lead and Manage E2</td></tr>
<tr><td>Increase Energy Efficiency of Weapons Systems, Platforms, Vehicles, and Equipment</td></tr>
<tr><td>Meet Operational Demand With Renewable Energy</td></tr>
<tr><td colspan="4"></td></tr>
<tr><td>Reduce Energy Intensity (EISA 2007)</td><td colspan="3">From 2003 to 2015, reduce energy intensity at installations by 30%</td></tr>
<tr><td>Reduce Water Consumption Intensity (EO 13514)</td><td colspan="3">Through 2020, reduce water consumption intensity by 2% annually</td></tr>
<tr><td>Increase Renewable Facility Energy (NDAA 2010)</td><td colspan="3">By 2020, increase amount of alternative energy consumed at installations to 50%</td></tr>
<tr><td>Decrease Petroleum Consumption (SECNAV)</td><td colspan="3">By 2015, decrease non-tactical petroleum use by 50%</td></tr>
</table>

Table 1. USMC Energy Goals (from USMC HQ, 2011, p. 21)

Although the focus of the USMC efforts is on expeditionary energy, USMC senior leaders believe that changes in energy use start at home on the bases. These leaders believe that such changes are about changing the culture and the way that all Marines think about energy. Additionally, they plan to focus on water usage because water is closely associated with energy and is also an important logistical concern in an expeditionary environment.

As seen in the first four goals listed in Table 1, the USMC's first expeditionary energy goal is to change the culture by integrating energy into everything they do. The second energy goal is to have systems in place by 2015 for leaders to monitor and manage energy and water use in all USMC materiel (USMC HQ, 2011). This is tied closely to the third goal, which is to increase energy efficiency of all USMC materiel. USMC materiel includes weapons systems, platforms, vehicles, and equipment (USMC HQ, 2011). The USMC will improve existing systems and obtain new systems with more efficiency. The fourth USMC expeditionary energy goal is to increase renewable and

storable energy resources for operational use in austere conditions. This latter goal will truly make the USMC lighter and more energy independent on the battlefield. The overall expeditionary goal is to increase energy efficiency by 50 percent and in turn decrease Marines' daily fuel usage by 50 percent (USMC HQ, 2011).

The USMC also has four non-expeditionary energy goals that are important to the energy strategy. These goals are centered around installations and are illustrated in the last four goals listed in Table 1. The first installation energy goal is to reduce energy intensity by 30 percent (Executive Order No. 13423, 2007). The USMC has already made great strides in reducing its energy intensity but has many more improvements to make to reach its goal. The goal will be attained by gaining efficiencies in all energy-related areas, including improving existing systems and replacing obsolete ones. In addition to making expeditionary energy improvements, the USMC will also establish an ability to monitor and manage energy. New technologies will replace old ones with state-of-the-art energy-efficient characteristics designed to reduce energy usage and costs. The second non-expeditionary goal is to reduce water consumption by two percent annually until 2020 (USMC HQ, 2011). This goal will be reached by improving existing systems and replacing obsolete ones. The USMC will reinforce the importance of water conservation by promoting it on base and extrapolating it to the battlefield. The third non-expeditionary goal is to increase alternative energy to 50 percent of total energy used on base by 2020 (USMC HQ, 2011). This goal will be reached by considerably reducing energy use and integrating renewable energy systems. The fourth non-expeditionary energy goal is to decrease non-tactical petroleum consumption by a 50 percent by 2015 (USMC HQ, 2011). This goal will be reached by acquiring all types of alternative fuel vehicles and the infrastructure to support them. This goal includes the use of military bases that use petroleum to generate energy.

The USMC plans to achieve these expeditionary energy goals incrementally because most of the goals will require time. Figure 1 illustrates a timeline to accomplish the ultimate goal of a 50 percent reduction in gallons per Marine per day (USMC HQ, 2011).

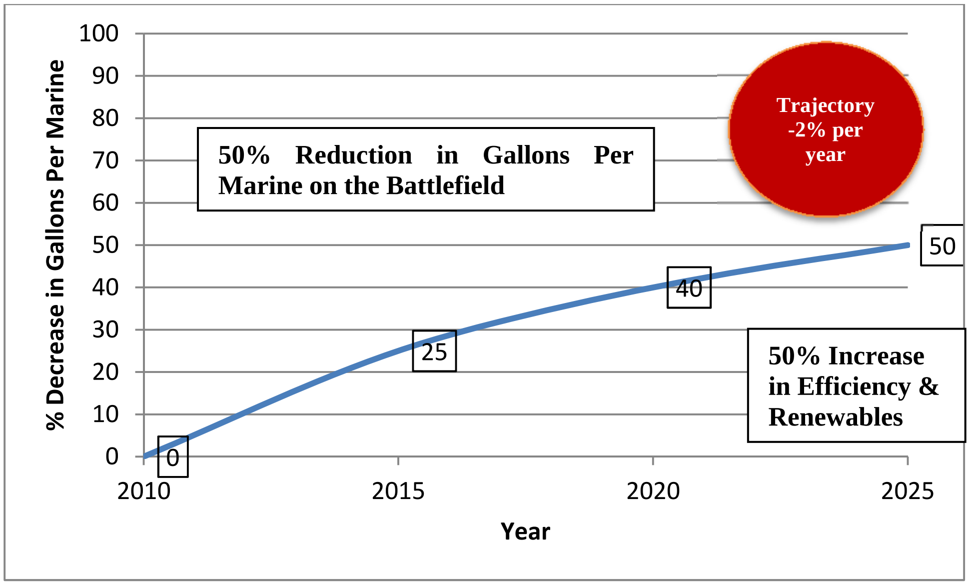

Figure 1. Gallons per Marine per Day Timeline (from USMC HQ, 2011, p. 25)

As actions are taken to achieve these goals, the USMC will see both short-term and long-term gains in energy efficiency, particularly with expeditionary water and energy consumption. The actions taken to achieve energy efficiency include the immediate improvement to existing materiel as well as efforts to change behavior. All of these changes start with leadership. The USMC's long-term plan includes investments in research and development (R&D) and acquiring new technology to meet requirements. The USMC believes that these efforts will allow it to ultimately achieve its goals and lead to savings (USMC HQ, 2011).

2. USMC Energy Initiatives

The USMC operationalizes its expeditionary energy strategy with a whole-of-service approach (USMC HQ, 2011). The whole-of-service approach examines every warfighting capability as explained in the *Joint Capabilities Integration and Development System* [JCIDS] (Chairman of the Joint Chiefs of Staff [CJCS], 2012a). The JCIDS is used to identify gaps in capabilities, so the USMC uses it as a guide for its expeditionary energy initiatives. The USMC categorizes its initiatives in the following manner: lead, man, train, and equip (USMC HQ, 2011). These categories serve as overarching themes in the USMC strategy.

The USMC believes that the foundation to a successful energy strategy starts with leadership. The USMC will inculcate all Marines with the importance of energy conservation and efficiency in everything they do at home and on deployment. This effort will require all leaders to participate. Leaders will be given the tools to monitor and regulate energy use within their units. Collecting energy information is important to identify shortfalls and gaps and also allow leaders to maximize efficiencies. The USMC will also lead in expeditionary energy by establishing requirements for expeditionary energy, water, and waste (USMC HQ, 2011). The USMC will use the JCIDS process to make these requirements programmatic and invest in them. The USMC will also work with other services and agencies to ensure unity of effort and select the best methods and technology available. Leaders will promote a climate of innovation and a sense of accountability throughout the ranks so every Marine feels that he or she is a part of the initiative.

The USMC is committed to manning and training the USMC. A key part of the expeditionary energy strategy is to have the right people and expertise in order to meet the energy goals. The USMC will ensure that all key energy positions are manned. Along with manning, training all Marines about energy is important. Training will occur in conjunction with new policy and doctrine and be instituted at all levels, particularly at the operational level. The training will ensure a fundamental understanding of the link between energy and combat effectiveness and lead to the USMC's success in future expeditionary environments (USMC HQ, 2011).

The USMC endeavors to be the leader in expeditionary energy. Through the various initiatives and equipping, it will attain this goal. Equipping the USMC with cutting-edge technology will give it the foremost warfighting capabilities to maintain its elite status. For materiel acquisition, the USMC will procure only the most energy-efficient platforms and systems while maintaining the same performance specifications of current platforms and systems. If economically feasible, the USMC will improve the old systems to meet the new energy requirements. But, ultimately, it is about getting the new technology to the end user. Marines will test and evaluate the technology at home but

quickly use them on the battlefield, particularly with energy-saving and renewable energy requirements generated from Afghanistan.

B. TRADITIONAL ACQUISITION

The DOD traditional acquisition process is very complex and lengthy. The main reason for this complexity is that the process integrates three decision support systems in order to modify or acquire new materiel or services (Department of Defense [DOD], 2013). These three systems are the JCIDS, the PPBE process, and the DAS. The PPBE process is used by the DOD to strategically plan and allocate resources. JCIDS is used to determine capabilities or requirements and then acquire those capabilities using the DAS (DOD, 2013). In short, the DOD identifies a need, funds it, and then acquires it, as shown in Figure 2.

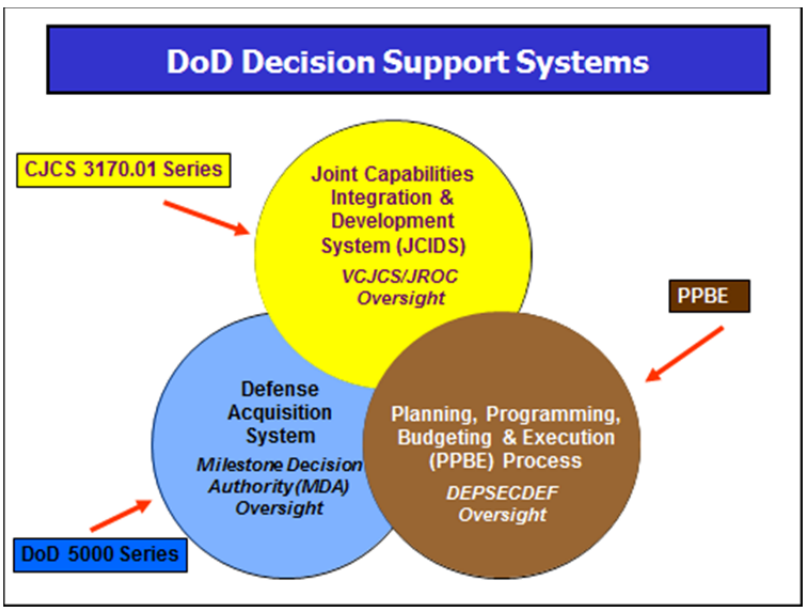

Figure 2. DOD Decision Support Systems (from DOD, 2013, p. 3)

These systems are all unique in terms of schedule, personnel, procedures, regulations, and oversight, which is another reason why the acquisition process is so complex and lengthy (Chyma, 2010).

1. JCIDS—Requirements

The JCIDS is the process used by the Joint Requirements Oversight Council (JROC) to advise the chairman of the Joint Chiefs of Staff (CJCS) in identifying, assessing, validating, and prioritizing capability requirements (CJCS, 2012a). The JROC actually oversees the process, and the Joint Staff J8 manages it. Services use a variation of this process to validate their own capability requirements when delegation authority has been granted to them. The JCIDS is the first step of the traditional acquisition process, and the result of this step is the creation of capability requirements.

The JCIDS is an iterative process, as shown in Figure 3. Although this process can be tailored based on urgent needs or faster fielding, it generally occurs in four phases. Phase One involves requirements identification and document generation. In this phase, the service conducts a capabilities-based assessment (CBA) in order to assess capability requirements and associated gaps (CJCS, 2012a). From the CBA, an initial capabilities document (ICD) is generated to identify mission-essential capability gaps in the capability requirements. The ICD then leads to materiel and non-materiel solutions to those gaps. As the acquisition process advances, a capability development document (CDD) is developed, followed by a capability production document (CPD).

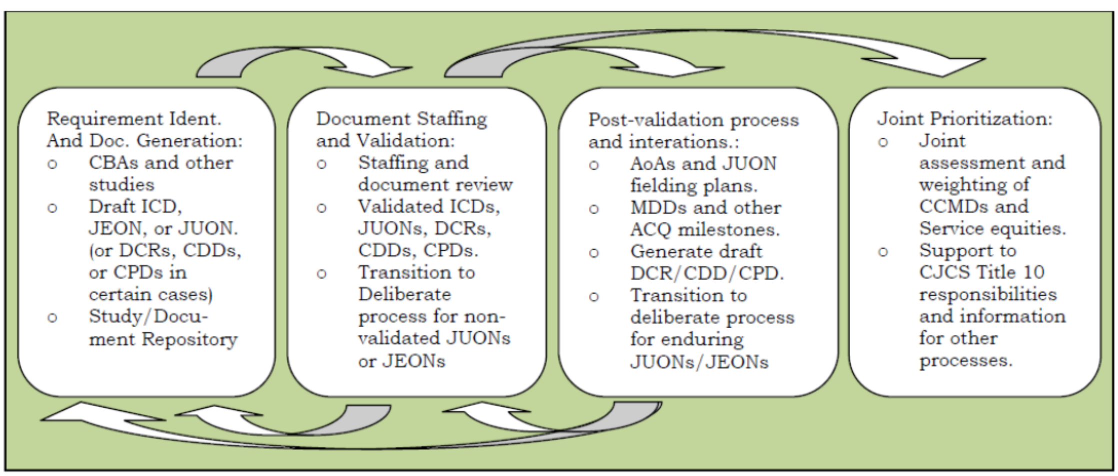

Figure 3. Overview of the JCIDS Process (from CJCS, 2012a, p. A-1)

Phase Two involves document staffing and validation. The level of staffing depends on the joint staffing designator (JSD), who indicates whether the capability requirements are unique to the service or are used jointly in multiple services. If they are joint capabilities, then the document staffing and validation flows from the sponsor to the JROC or the Joint Capabilities Board. If the capability is unique to the service, the service has validation authority. The staffing and validation of the ICD, CDD, and CPD also vary depending on urgency and technical complexity. For example, with commercial off-the-shelf (COTS) items, an ICD may lead directly to a CPD because development is minimal or unnecessary.

Phase Three involves post-validation processes and interactions. In this phase, materiel and non-materiel solutions activities begin. The materiel solution starts the DAS process, and a draft CDD and CPD are generated accordingly. The CDD and CPD then return to the staffing and validation phase.

Phase Four involves joint prioritization. This is the JROC's and CJCS's responsibility and requires capability prioritization for decision-makers. Each functional capability board also prioritizes capability requirements into joint priority. This is done to facilitate staffing but can be time-consuming. The priority is important because it determines what gets resourced in the PPBE process.

The gatekeeper plays a key role in the JCIDS process because he or she manages the overall flow of documents for staffing and validation (CJCS, 2012b). This role as well as the entire JCIDS process has improved in the last few years. In the past, the Joint Staff J8 advertised four to six months as the average duration each time a document was sent through for validation. Another source claimed that the process took nine to 12 months, depending on the JSD (Chyma, 2010). Figure 4 shows the changes and improvements to the staffing and validation portion of the JCIDS process.

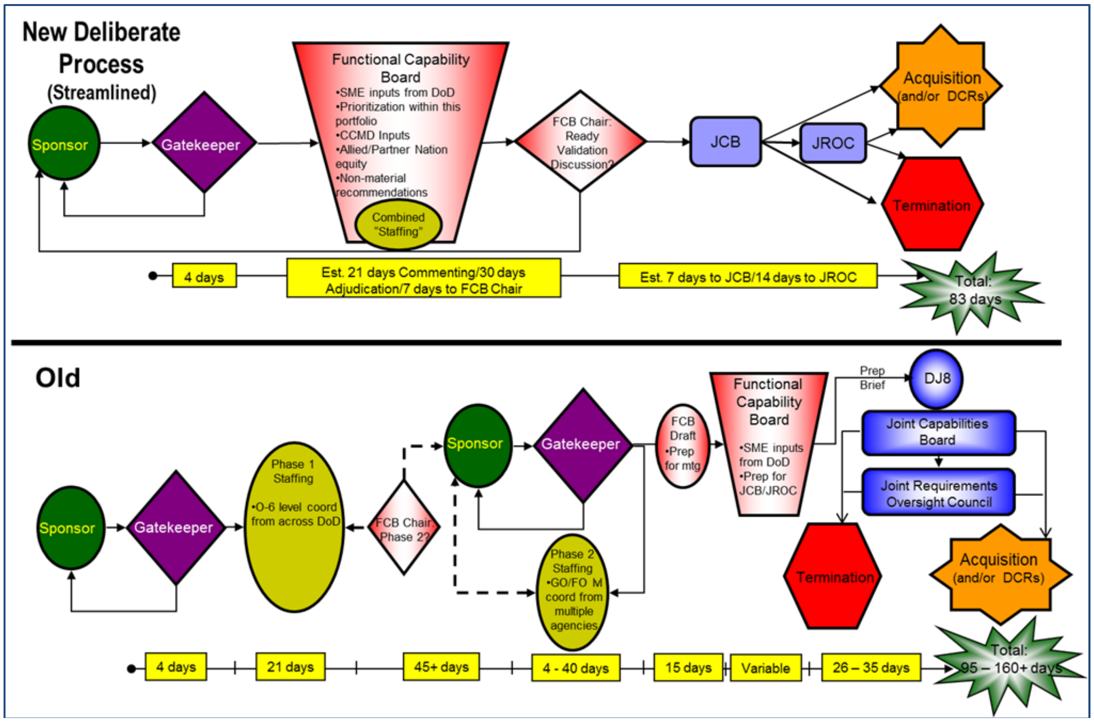

Figure 4. JCIDS Staffing and Validation Process (from Willis, 2012)

Compared to the old process, the new deliberate process essentially cuts the process duration by a quarter to a half. Although this is a big improvement, it does not improve the overall process by much because of the interaction with the DAS and the PPBE process. The deliberate (traditional) process still needs between two and six or more years, as seen in Figure 5.

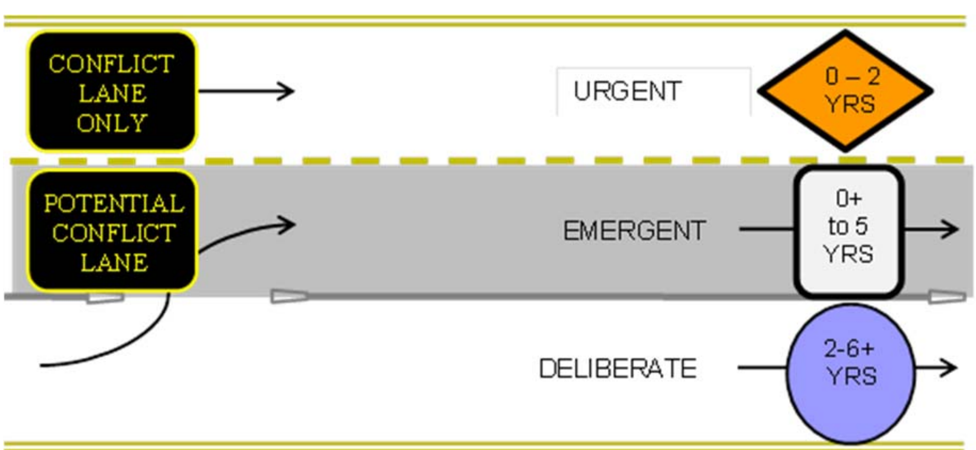

Figure 5. Three Requirements "Lanes" (from Willis, 2012)

The three requirements lanes are deliberate, emergent, and urgent, with certain criteria to use each lane. The traditional or deliberate process is used when technology development is significant or the capability is not time sensitive—essentially, there is no wartime need. It is important to note the timing for the staffing and validation process because this does factor into the overall process duration. The urgent and emergent lanes fall under rapid acquisition and are covered in the rapid acquisition section.

Also intertwined within the JCIDS process is the USMC role. The USMC is actively involved and leading the CBA and any documents resulting from the CBA. These documents are then reviewed on a deliberate schedule for all USMC requirements called the "Solutions Analysis Process" (Magnus, 2008). For example, the ICD which results from the CBA goes through three distinct steps (Magnus, 2008):

1. Step one: Conduct doctrine, organization, training, materiel, leadership and education, Personnel, and Facilities (DOTMLPF) analysis from October of even years to January of odd years

2. Step two: Implement solution planning directive (SPD) from February to May of odd years

3. Step three: Develop MAGTF requirements list from June to August of odd years

This process culminates in MROC approval and then proceeds through the JCIDS staffing and validation process as described above. The process is also iterative so it will occur two more times for the CDD and CPD.

a. CBA

The JCIDS initiates the early acquisition process and also interacts throughout the process with the DAS and PPBE. In the initial stage of the process, a capabilities-based assessment (CBA) is conducted on USMC expeditionary energy, water, and waste requirements. The CBA team considers the current strategic guidance as well as the full spectrum of operations to be assessed. The objective of the CBA is to identify gaps in the capability gaps and solutions to those gaps. Usually these gaps result in an ICD, which leads to materiel or non-materiel solutions to capability gaps.

The Expeditionary Energy Office (E2O) sponsored a CBA to document capability gaps and solutions for USMC expeditionary energy, water, and waste requirements. The CBA's objective was to meet the goals of the USMC expeditionary energy strategy: to reduce the fuel used per Marine by 50 percent, improve water self-sufficiency, and better manage waste (U.S. Marine Corps Expeditionary Energy Office [USMC E2O], 2011). The CBA team consisted of various leaders throughout the USMC, other services, and partners. The scope of the CBA looked specifically at operations originating from the sea and the first 120 days on land. The CBA team concentrated only on these criteria because the U.S. Army was simultaneously conducting a study of enduring operations on land. As shown in Figure 6, the CBA team's method for assessing operations involved identifying capability gaps, assessing risk, and recommending solutions. The CBA team concluded its assessment by providing materiel and non-materiel solutions in the corresponding ICD, which we detail in the next section.

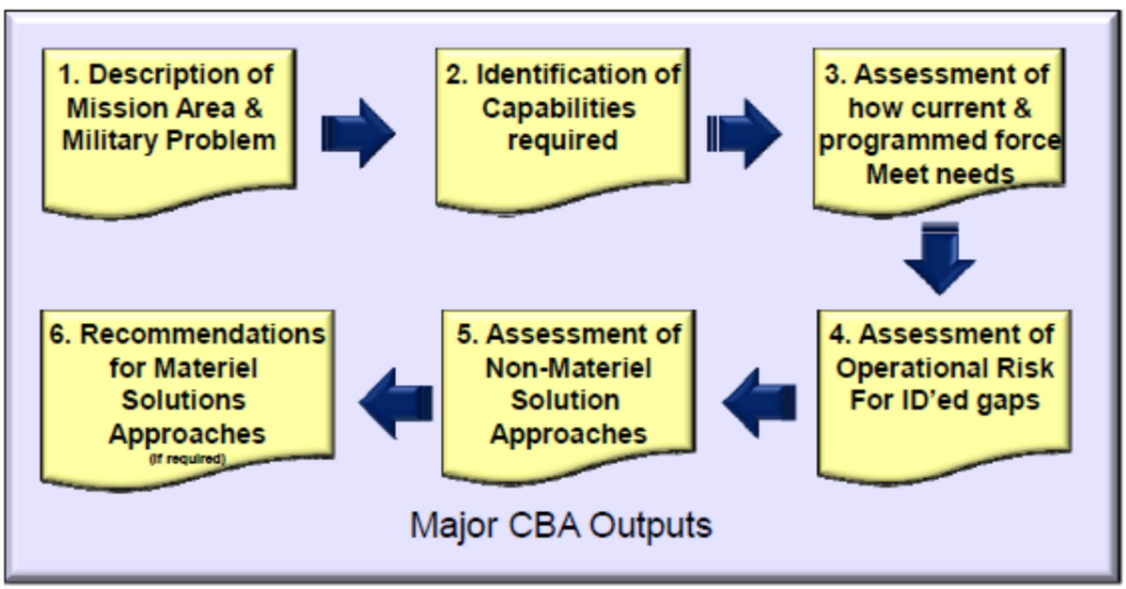

Figure 6. CBA Flow Process (from USMC E2O, 2011, p. E-2).

b. ICD

The ICD is a product of the JCIDS and a key document in the JCIDS process. This section draws heavily from *USMC Initial Capabilities Document for Expeditionary*

Energy, Water, and Waste, which was completed in September 2011. The ICD is organized as a concept of operations (CONOPS) with the objective of forming the intellectual base for capabilities-based planning to accomplish the goals in the USMC expeditionary energy strategy (USMC E2O, 2011). This section summarizes key findings in the E2O-sponsored ICD and discusses the way ahead.

The CBA team examined expeditionary energy, water, and waste across a range of expeditionary operations. From these expeditionary operations, the CBA team identified the required capabilities. The team then determined tasks and other actions that would be needed to achieve those capabilities. Twenty-nine tasks were defined within the three expeditionary energy lines of operation: procurement of new technology and improvement of existing materiel, increased renewable energy use, and an ethos that associates energy and water with battlefield effectiveness (USMC HQ, 2011). These tasks are both institutional and operational.

Once the CBA team identified required capabilities, it could then identify capability gaps. The CBA team combined the USMC expeditionary energy strategy with lessons learned and CONOPS developed for the CBA in order to set standards for gap and risk assessment (USMC E2O, 2011). The assessment resulted in the identification of 152 capability gaps. Gaps were categorized in the following manner: policy, sufficiency, proficiency, lack of capability, need for replacement, or recapitalization (USMC E2O, 2011). The CBA team also ranked the gaps in priority order with the corresponding tasks and capability requirements. (See the ICD in USMC E2O [2011] for further detail). After identifying the gaps, the CBA team proposed non-materiel and materiel solutions to address the gaps.

(1) Non-Materiel Solutions. The CBA team recommended 160 non-materiel solutions that have both short- and long-term effects (USMC E2O, 2011). Many of these solutions involve institutional changes that can quickly mitigate some of the identified capability gaps. The first recommended institutional change starts with USMC policy. We highlighted some of the policy changes and additions in the preceding USMC expeditionary energy strategy section, but the CBA team identified more during their assessment. For example, one change requires that energy policies be published to guide

the JCIDS process. Also, new policies on water use and batteries need to be implemented. The bottom line is that policies will be published to help solve all of the capability gaps.

The CBA team used the DOTMLPF to categorize the other non-materiel solutions. Overall, current USMC doctrine was found to be deficient in the areas of energy, water, and waste. Future doctrine will address these areas and provide guidance to USMC personnel on constructing efficient FOBs and conducting expeditionary operations (USMC E2O, 2011). The organization category will also be updated to account for the expeditionary energy, water, and waste requirements. These solutions involve manpower and specifically target tables of organization and equipment, which are the organizational tools that establish the staffing and equipping of units. Training is also a fundamental solution to the capability gaps. Training will be updated to include general awareness, planning, and management of expeditionary energy, water, and waste for current and future operations (USMC E2O, 2011). Changes in training will also be made to individual specialties to account for the new capabilities. Generally, training in the areas of energy, water, and waste will be integrated into all administrative and operational environments. Personnel changes are also required as part of the solution. Following closely with organizational tools, these changes involve in-depth changes to manpower and tasking, including establishing new and modifying current military occupational specialties in the areas of expeditionary energy, water, and waste. The proper personnel will be assigned to units in order to meet new requirements and manage new capabilities. In regard to facilities, the expeditionary solution is quite simple and involves designing models of scalable FOBs for various types of missions and durations (USMC E2O, 2011). Leadership is the key element to implementing these solutions because it will require everyone to make these changes effective. Additionally, education across the USMC at the individual and unit levels will be needed to change the culture and achieve the USMC expeditionary energy, water, and waste goals.

(2) Materiel Solutions. The expeditionary energy, water, and waste capability gaps that could not be solved by the non-materiel solutions were potentially solved with materiel solutions. The CBA team identified 87 materiel solutions, which are categorized

by one of the following: IT, evolutionary development, and transformational (USMC E2O, 2011). The 87 materiel solutions relate to 27 of the 29 tasks mentioned previously (USMC E2O, 2011). These solutions were in addition to 22 materiel solutions that were discovered through other research (USMC E2O, 2011). Based on the distribution of capability gaps within the categories, many existing and planned initiatives will meet the capability gaps but much more is needed in the IT realm.

IT is a critical part of the expeditionary energy, water, and waste capabilities. Better IT will allow leaders to monitor and manage energy and water consumption. IT will also provide a database for all users to store analytical information. These are just a few of the IT solutions.

Evolutionary development involves materiel solutions that change or upgrade existing technologies for better performance or capability. For example, one approach is to modify COTS items for use in expeditionary environments (USMC E2O, 2011). Evolutionary development also includes approaches to solutions in the following areas (USMC E2O, 2011):

- develop renewable power systems for unit and individual use,
- develop FOB modules for efficient utilities support, and
- develop and field water test kits or upgrade existing kits.

The USMC uses other evolutionary solutions, but we have highlighted these approaches here because of solutions completed in these areas. The ExFOB is involved in these materiel solutions, which is discussed further in the ExFOB section.

The transformational approach involves developing new technologies as an approach to materiel solutions. For example, one approach is to develop “hybrid”-fuel-burning generators that have storage and renewable-energy capabilities (USMC E2O, 2011). All of the approaches in this category are cutting edge and essential to achieve the USMC expeditionary energy, water, and waste goals. The ExFOB is involved with these materiel solutions as well.

2. PPBE—Resourcing

The PPBE process is how the DOD allocates resources. This is a very complex and lengthy process that requires particular attention to the timing of events. The priorities of the DOD are balanced with fiscal constraints, and this balance is conducted through a four-phase overlapping process (DOD, 2013). The four phases are planning, programming, budgeting, and execution.

The planning phase involves the Office of the Secretary of Defense, Joint Staff, and DOD components. Their efforts are led by the *Defense Planning Guidance* (DPG), which incorporates the national strategies within fiscal limits. The phase results in the following: "guidance and priorities for military forces, modernization, readiness and sustainability, and supports business processes and infrastructure activities" ("PPBE Process: Planning Phase," n.d.).

The programming phase involves a response to the DPG by the DOD components. As part of the response, the components develop program objective memorandums (POMs). The POM describes the proposed programs and a time-phased allocation of resources by program for a five-year period (DOD, 2013). All of the POMs are reviewed and eventually integrated into a comprehensive defense program. This program then results in the defense budget and the Future Years Defense Program (FYDP).

The budgeting phase and programming phase occur simultaneously, as suggested previously. With each POM submitted, a budget estimate submission (BES) is also submitted. The budget is only for one year, and the BES provides more detail so it can be reviewed. The final version of the budget is then incorporated into the defense budget and FYPD.

The execution phase also occurs concurrently with the budgeting and programming phases. In this phase, a review of new and previous programs is conducted. From the review, program adjusting or restructuring may occur (DOD, 2013).

PPBE is a biennial cycle, which complicates the entire PPBE process even more. The PPBE process is done to support a two-year budget. In even years, also called on years, the budget is submitted to align with the DOD budget that is part of the President's budget to Congress. However, Congress only appropriates annual defense budgets so an amended budget has to be submitted in the odd years, called off years, for the subsequent year's appropriation. The off years are very restrictive in that only minor program or budget adjustments can be made (DOD, 2013). Therefore, timing of this process is very important with respect to new requirements, and components need to focus on the on years in order to minimize the overall time. Figure 7 illustrates the overlapping budget cycles.

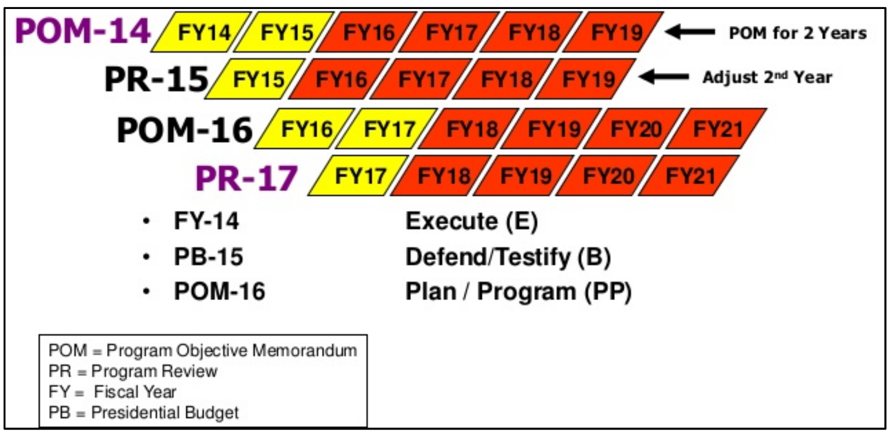

Figure 7. Overlapping Budget Cycles (from Minstral, 2013).

3. Defense Acquisition System

Once a CBA has been completed and an ICD directing a materiel solution has been generated through the JCIDS process, the USMC uses the DAS to deliver the required capability. All acquisition programs follow the generic framework illustrated by Figure 8.

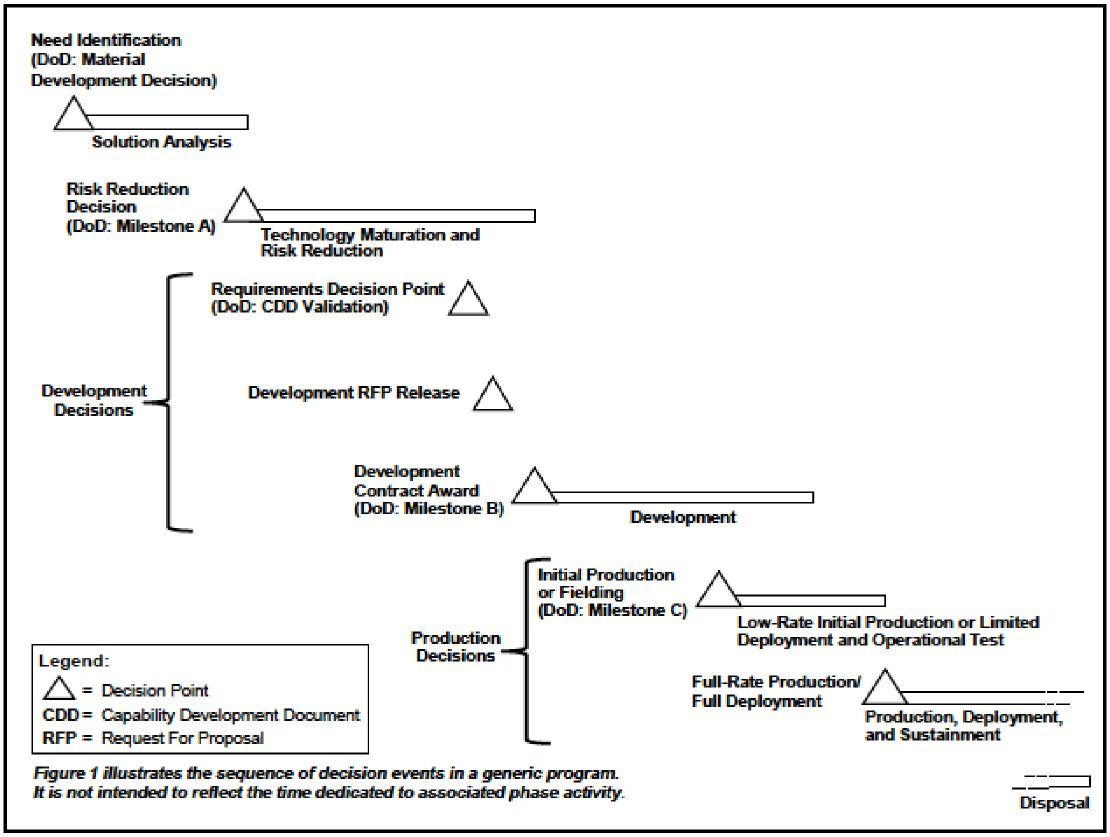

Figure 8. Generic Acquisition Phases and Decision Points (from Kendall, 2013, p. 7)

The majority of weapons systems and support equipment that are not heavily reliant on technology use the framework outlined by Figure 9 to develop, test, produce, and support the newly acquired capability.

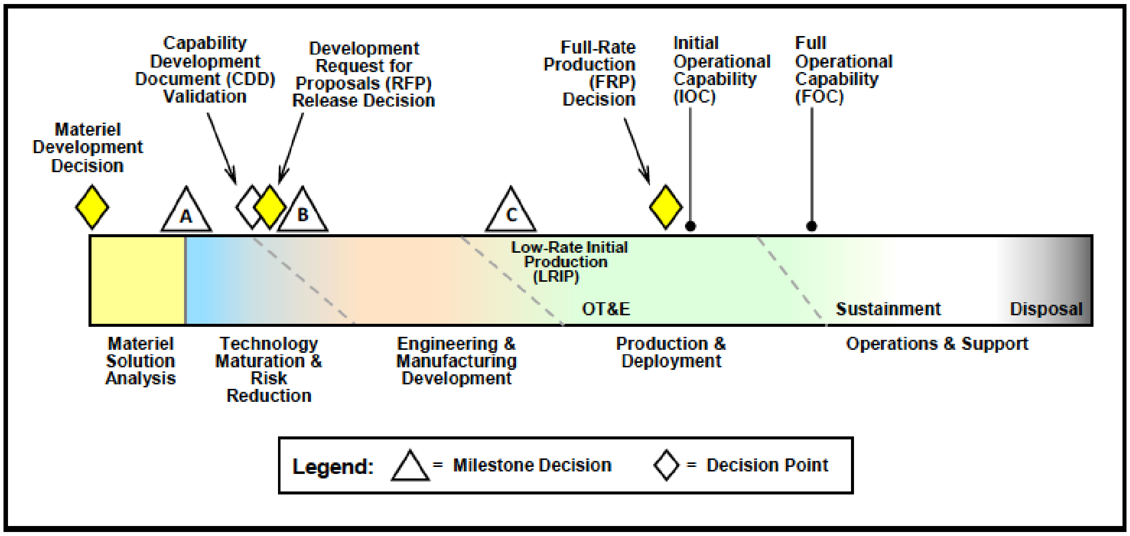

Figure 9. Hardware Intensive Program (from Kendall, 2013, p. 9)

Once a materiel solution has been directed, the first step in acquiring a new capability is to perform the materiel solution analysis. This phase is entered when the milestone decision authority (MDA) makes the material development decision. By making this decision, the MDA approves the analysis of alternatives study guidance (which directs the examination of the best way to meet the capability gap), determines the acquisition phase of entry and identifies the initial review milestone, among other things (Kendall, 2013, p. 15).

During the materiel solutions analysis phase, the team conducts the analysis of alternatives (AoA). The AoA focuses "on identification and analysis of alternatives; measures of effectiveness; key trades between cost and capability; total life cycle cost, including sustainment; schedule; concepts of operations; and overall risk" (Kendall, 2013, p. 16). The program is ready to move out of the Materiel Solutions Analysis phase when the responsible DOD component has completed the work necessary to support proceeding "to the next decision point and desired phase in the acquisition process" (Kendall, 2013, p. 16). Assuming that the program is going to require the complete acquisition process to fulfill the validated requirement, the next step is to complete Milestone A and move the program into the Technology Maturation and Risk Reduction (TMRR) phase.

The Milestone A decision is approved by the MDA after the responsible program manager (PM) and DOD component present their acquisition plan for "the preferred material solution including: the Acquisition Strategy, the business approach, an assessment of program risk and how specific technology development and other risk mitigation activities will reduce the risk to acceptable levels, and appropriate 'should cost management' targets," as well as an assessment of the component's budgetary ability to sustain the program over its life cycle (Kendall, 2013, p. 17).

The TMRR phase is in place to "reduce technology, engineering, integration, and life cycle cost risk to the point that a decision to contract for EMD [Engineering and Manufacturing Development] can be made with confidence in successful program execution for development, production, and sustainment" (Kendall, 2013, p. 18). The actions in this phase will usually involve competitive technology sourcing, prototyping (of the entire system or selected critical components) and demonstrations. While the technology matures (and while early design decisions are still being made), the PM updates the acquisition strategy and begins planning for the sustainment phase of the program. Also during this phase, all stakeholders validate the CDD to ensure that the technology being developed will deliver the required capabilities in an effective and affordable way. Once the CDD is validated, a request for proposal is released, allowing contractors to make bids for the Engineering and Manufacturing Development (EMD) phase. Before the EMD contracts are awarded, a preliminary design review is conducted to gauge "the maturity of the preliminary design supported by the results of requirements trades, prototyping, and critical technology demonstrations" (Kendall, 2013, p. 87) and to ensure that the system is ready to pass Milestone B and move to the EMD phase.

The completion of Milestone B is required for entry into the EMD phase and is the true initiation of an acquisition program. After the MDA is satisfied that "all sources of risk have been adequately mitigated," it approves program initiation and the DOD components use of funding resources for the program, low-rate initial production (LRIP) quantities, and exit criteria for the next phase (Kendall, 2013, p. 23).

The EMD phase is composed of two parts: completion of the detailed design and developmental test and evaluation (DT&E). The design phase is based around the

systems engineering process and may necessitate multiple iterations and prototypes before the initial design reaches a final version that adequately fulfills the project requirements. Once the design is finalized, DT&E events are used to make sure the system can "provide effective combat capability, including its ability to meet its validated and derived capability requirements" (Kendall, 2013, p. 24). The production-representative prototypes used for successful DT&E are the basis for starting LRIP and/or limited deployment. The system moves on to the next phase

> when: (1) the design is stable; (2) the system meets validated capability requirements demonstrated by developmental and initial operational testing as required in the TEMP [Test and Evaluation Master Plan]; (3) manufacturing processes have been effectively demonstrated and are under control; (4) industrial production capabilities are reasonably available; and (5) the system has met or exceeds all directed EMD Phase exit criteria and Milestone C entrance criteria. (Kendall, 2013, p. 25)

Milestone C is a critical decision point for a system in the acquisition process. This is the point where a program is reviewed and approved to begin the production and deployment phase (Kendall, 2013, p. 26). Because much of the program's cost is generated in this phase, the entrance requirements to pass Milestone C are high. In addition to meeting the criteria laid out in Milestone B, there must be the following:

> An updated and approved Acquisition Strategy; demonstration that the production design is stable and will meet stated and derived requirements based on acceptable performance in developmental test; an operational assessment; mature software capability consistent with the software development schedule; no significant manufacturing risks; a validated Capability Production Document or equivalent requirements document; demonstrated interoperability; demonstrated operational supportability; costs within affordability caps; full funding in the FYDP; and properly phased production ramp up and/or fielding support. (Kendall, 2013, p. 26)

As the name implies, the production and deployment phase is where the product is produced and delivered to operational units. Depending on the type and quantity of the system being produced, this phase may be broken into smaller parts in order to mitigate the risks associated with acquiring large numbers of expensive items. These parts may include LRIP, limited deployment, operational test and evaluation (OT&E), and the full-

rate production decision or full deployment decision followed by full-rate production or deployment (Kendall, 2013, p. 27).

An initial run of LRIP items has multiple benefits. Initially producing only a small number of items allows a smooth transition to full-scale production and provides OT&E test samples. In the event that changes are required, these OT&E samples can provide critical feedback about the performance and production processes before too many out-of-spec units are produced.

Using the items produced during either EMD or LRIP to conduct OT&E is the final chance to evaluate the production items in the threat environment they were designed for. If no pre-production or LRIP samples are made, then the contractor must provide samples from the production process. In either case, the MDA will use the results of the OT&E to determine if the program is ready for full-rate production or full deployment.

Once the item has successfully completed OT&E and any remaining deficiencies have been corrected, the MDA authorizes full-rate production or full deployment. The remaining items are then produced and delivered, or full deployment begins.

Operations and support is the final phase of acquisitions and consists of two parts: life-cycle sustainment and disposal. Life-cycle sustainment ensures that adequate funding is programmed to provide training, support, maintenance capability, tools, equipment, etc. over the expected life of the product. The program manager (PM) is responsible for monitoring the program throughout its life cycle, looking for ways to save money, correcting trends away from program baselines, and being prepared to analyze requested upgrades to the program as technology and/or threats change.

Finally, the PM must ensure that there is a plan and matching funding so that at the end of its service life, the "system will be demilitarized and disposed of in accordance with all legal and regulatory requirements and policy relating to safety (including explosives safety), security, and the environment" (Kendall, 2013, p. 29).

C. EXFOB CHARTER

Lieutenant General Richard Mills, who is USMC deputy commandant for Combat Development and Integration (DC CD&I), formalized the ExFOB on March 28, 2012, with the ExFOB Charter. However, the CMC created the ExFOB concept in late 2009, and the first ExFOB was established in Quantico, Virginia, in early 2010. The second ExFOB was established in Twentynine Palms, California, in late 2010. The concept of the ExFOB was to facilitate a convention where industry could demonstrate its technologies to reduce the USMC's reliance on fuel and water (USMC HQ, 2012). The ExFOB's mission is stated as follows:

> The ExFOB Executive Integrated Planning Team (EIPT) will conduct a semi-annual field demonstration to identify, evaluate, and accelerate material solutions to fulfill identified capability gaps and increase energy efficiency as established in the reference [*United States Marine Corps Expeditionary Energy Strategy and Implementation Plan*]. (USMC HQ, 2012, p. 2)

Since the demonstration is semiannual, it is held at Quantico and Twentynine Palms each year. This allows demonstrations in different environments and under a range of conditions. This section draws heavily from the ExFOB Charter (USMC HQ, 2012).

1. ExFOB Concept of Operations

The ExFOB EIPT is in charge of all ExFOB activities and provides the final approval on which technologies to test and evaluate. As mentioned previously, industry demonstrates its technologies to the ExFOB team in order to meet USMC expeditionary energy, water, and waste requirements. The EIPT focuses on up to two capability gaps in each ExFOB, as identified in the *USMC Expeditionary Energy, Water, and Waste ICD* (USMC HQ, 2012). As seen in Figure 4, the USMC E2O conducts the day-to-day operations by coordinating, managing, and funding the subsequent test and evaluation of potential technologies, as depicted in USMC HQ (2012).

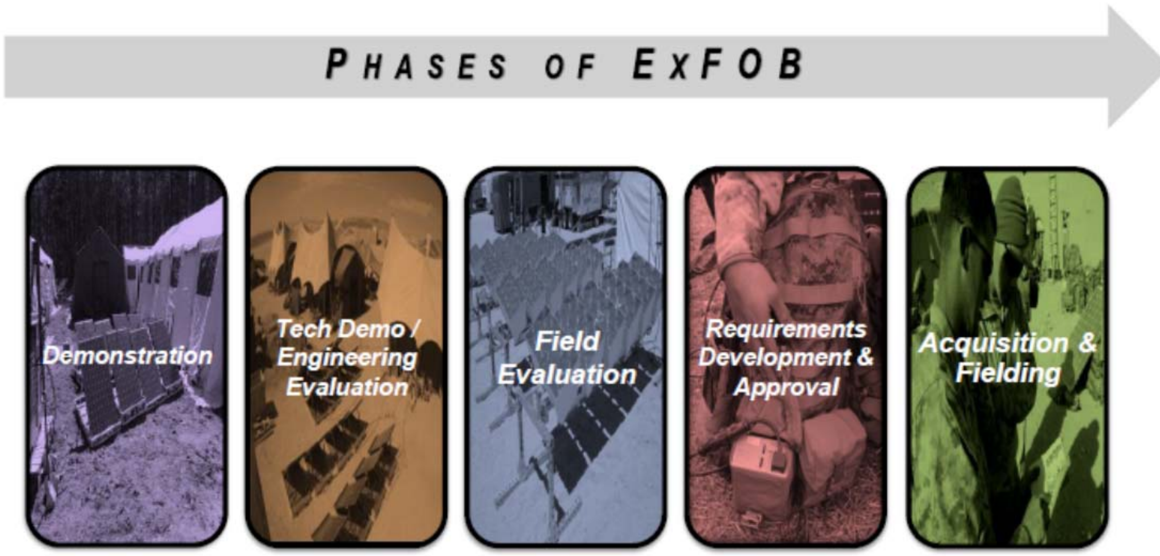

Figure 10. ExFOB Process (from USMC HQ, n.d.-a)

a. Demonstration

The demonstration phase involves the aforementioned semiannual demonstrations. Prior to each of these demonstrations, the ExFOB team sends out a request for information to industry regarding specific capability gaps. Industry replies with solutions, which the ExFOB team thoroughly reviews. The ExFOB team invites some companies to the ExFOB demonstration for a week in order to demonstrate their products (USMC HQ, n.d.-a). An ExFOB technical team captures performance information as well as feedback from Marines during the demonstration. A report is drafted with the results.

b. Technology Demonstration and Engineering Evaluation

The ExFOB team uses the report to decide which systems should be further evaluated. A small number of systems are then purchased for technology demonstration and engineering evaluation in a controlled environment (USMC HQ, n.d.-a). The evaluation team has manufacturers make modifications as needed in order to meet USMC requirements.

c. Field Evaluation

Systems that pass the technology demonstration are then sent for extended evaluation in the field. The field evaluation is where the systems really get tested. Field evaluations are done in both training and combat environments. This is conducted mostly stateside but is also performed overseas.

d. Requirements Development

Feedback from the field is provided to manufacturers so that they can then make any necessary modifications. The main output from the evaluation, however, is the development of a written military requirement (USMC HQ, n.d.-a).

e. Acquisition

Acquisition of the system follows the formal requirement process (JCIDS), which also includes PPBE and DAS. The USMC then acquires the capability in order to meet a capability gap identified in the *USMC Expeditionary Energy, Water, and Waste ICD* (USMC HQ, 2012).

2. ExFOB Stakeholders

The ExFOB brings together stakeholders from the services, industry, and academia. The ExFOB Charter delineates specific tasks for many of the stakeholders in order to make the ExFOB effective. First and foremost, the Marine Corps Warfighting Laboratory (MCWL) chairs the EIPT. The MCWL has a number of tasks and oversees the ExFOB process because their mission, in general, is to test and evaluate USMC concepts in order to validate, modify, or reject them. The DC CD&I is also a key stakeholder with many tasks to perform. One of these tasks is to coordinate with other stakeholders such as the Office of Naval Research (ONR) and Training and Education Command regarding solutions implementation, which occurs when technologies advance through the ExFOB process. The ExFOB Charter also requests support from a number of stakeholders such as Marine Corps Systems Command, ONR, the USMC E2O, and legal.

All of these stakeholders are participants in the preparation and execution of the ExFOB. ONR has the additional duty to engage with other research components, industry, and academia every few years to offer challenges specific to expeditionary energy, water, and waste capability gaps (USMC HQ, 2012). The USMC E2O has the biggest role in coordinating and overseeing all ExFOB activities. The E2O is essentially the operations department for the ExFOB and day-to-day operations in taking new capabilities "from concept to combat" (USMC HQ, n.d.-b).

3. ExFOB Today

In the past six years, the ExFOB has made great strides with quick materiel solutions. As the program matured, the ExFOB team has been able to do more and more. To date, the ExFOB team has assessed nearly 300 technologies and evaluated over 100 technologies (USMC HQ, n.d.-b). It has also procured and deployed 11 systems to Afghanistan, of which four are now USMC programs of record (PORs; USMC HQ, n.d.-b). The fiscal year (FY) 2013 budget was about $2.4 million and is expected to increase in the future, with many capability gaps still to be solved.

D. ARMY RAPID ACQUISITION

The wars in Iraq and Afghanistan underlined the need for rapid acquisition of materiel solutions. The traditional acquisition system, the DAS, was too slow in responding to emergent requirements on the battlefield. The battlefields in Iraq and Afghanistan were very dynamic, and the enemy was quick to adapt, so the threat was constantly changing. General Petraeus, then commander of U.S. Central Command, stated, "Never, never underestimate how important speed is. We need what we need now. As a threat emerges, we need to counter it rapidly" (Petraeus, 2010, p. 5). As a result, all services responded by creating rapid acquisition organizations. The REF is one option for Army rapid acquisition.

1. REF

The U.S. Army established the REF in late 2002 in order to help solve the rapid acquisition problem. The mission of the REF is as follows:

> The Rapid Equipping Force (REF) harnesses current and emerging technologies to provide rapid solutions to the urgently required capabilities of US Army forces employed globally. (U.S. Army Rapid Equipping Force [REF], n.d.)

The REF uses current and emerging technologies in the form of government off-the-shelf or GOTS. Similar to the ExFOB, the REF canvasses the government, industry, academia, and science communities for existing and emerging technologies (U.S. Army Headquarters [HQ], 2009).

Rapid acquisition of materiel solutions is concerned with equipping as opposed to fielding. Fielding uses the DOTMLPF approach in order to find a force-wide solution: the traditional DAS, which is a very deliberate, timely, and regulated process. Equipping, on the other hand, is focused on operational needs, so it is a quick, short-term solution. The REF standard for materiel solutions is an "acceptable" (51% solution) performance criterion, which is drastically different from the high standards demanded in traditional acquisition (U.S. Army, 2010).

2. REF Process

The REF process is very similar to the ExFOB process discussed previously and consists of four phases—requirements, materiel solution, deployment, and transition—as shown in Figure 11. Figure 11 also shows (with starred points) the four key decisions made by the REF director: requirement and director intent approval, cost/schedule/ performance approval, equip decision, and disposition decision.

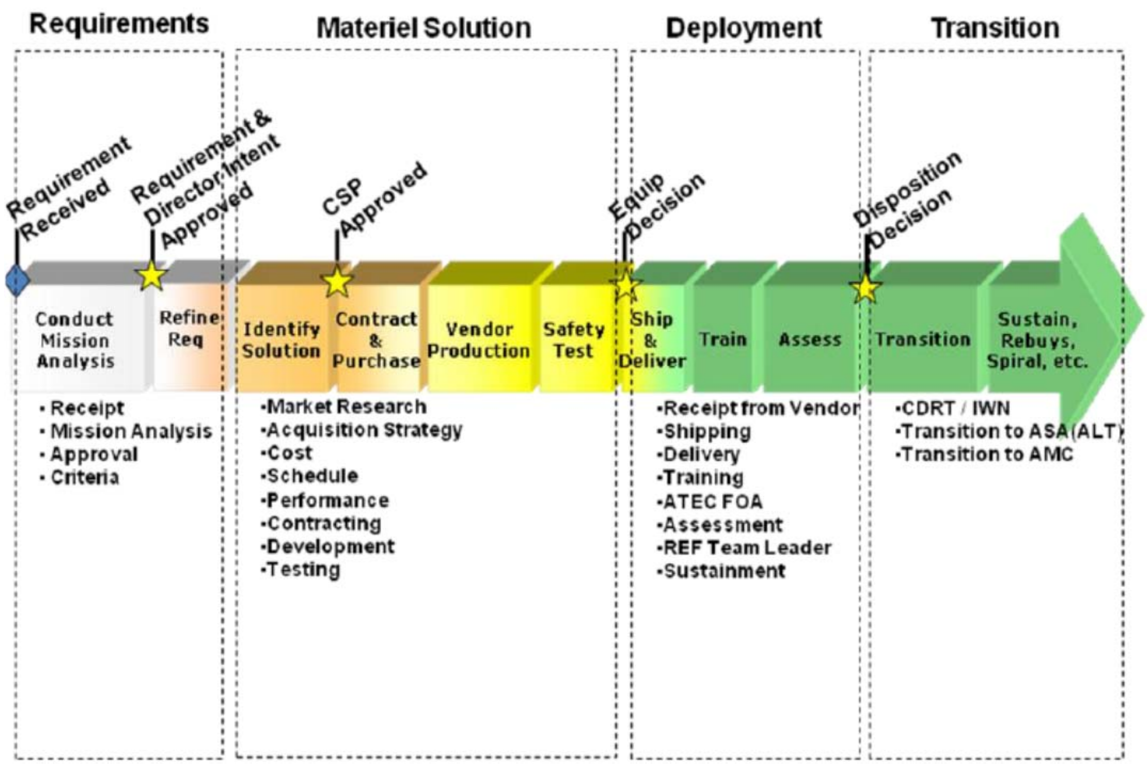

Figure 11. REF Process (from Baldauf & Reherman, 2011, p. 40)

a. Requirements

Similar to the JCIDS, the REF's requirements phase includes identifying, assessing, and prioritizing capabilities needed to complete the mission. This phase begins by receiving requirements from a number of sources. The REF team then analyzes the received requirements to provide recommendations to the REF director. The director then decides which requirements to pursue and if any requirements need to be refined.

b. Materiel Solution

The materiel solution phase begins with identifying a solution. The REF team formally and informally conducts market research with industry, academia, and government. This research results in an acquisition strategy and the director's decision on how to proceed. The process continues with contracting, purchasing, and production. The final step is testing and the director's decision to move to the deployment phase.

c. *Deployment*

The deployment phase is used to evaluate the system in a training and operational environment. The system is shipped and delivered to the unit whether it is stateside or overseas. The REF team ensures that the units are trained, and the assessment begins immediately. The final step is for the REF director to review all of the assessment data and decide whether to move to the transition phase, terminate, or continue for a limited period.

d. *Transition*

The REF director's decision is sent to the Army Research, Development, and Engineering Command for another disposition decision. This disposition decision goes to the Army Capabilities Integration Center for a final disposition decision before proceeding through the Capabilities Development for Rapid Transition (CDRT) process. The CDRT process establishes the capability for life-cycle sustainment.

3. REF Timeline

The REF's scope has made it very successful in providing materiel solutions in a timely manner. Since its inception, the REF has introduced many types of equipment to meet urgent warfighter needs. Because the REF targets existing and emerging technologies, the solution timelines are very short, as illustrated in Figure 12.

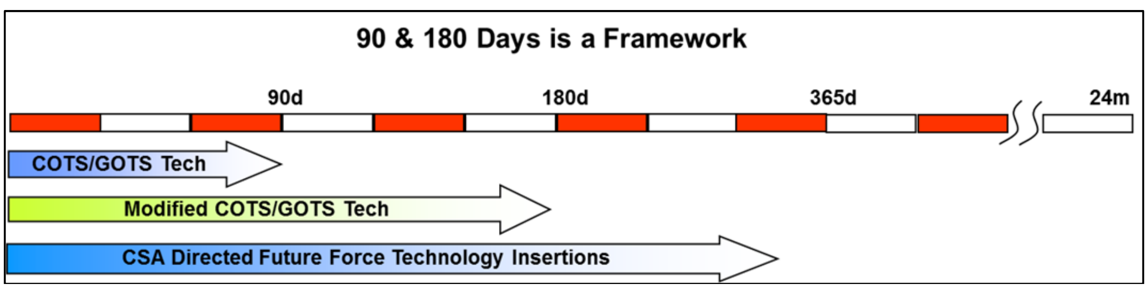

Figure 12. REF Timeline (from U.S. Army HQ, n.d.)

The timeline is largely driven by the complexity of the solution as well as the existing technology. If the technology exists, it takes 90 days on average to deliver a solution. If the technology has to be modified, it takes 180 days on average. Finally, if the technology is emerging or has to be developed, it takes 365 days on average. As of 2007, the average time for all technologies to go from request to initial operating capability was 128 days (Chyma, 2010).

4. REF Energy to the Edge Program

In FY2011, the REF started the Energy to the Edge program in response to expeditionary energy and water requirements. The program's goals are to meet combat units' expeditionary needs more efficiently and thereby reduce fossil fuel consumption and reliance on logistical resupply ("Taking Alternative Energy," 2013). The REF meets these goals by working with a number of partners to identify and evaluate alternate energy systems. Generally, the REF team takes a "hybrid approach," which is a mix of energy sources and technologies ("Taking Alternative Energy," 2013). In early 2012, the REF deployed a variety of systems to Afghanistan that either reduced or removed the requirement for fuel. These systems have had great results and will continue to be improved with feedback from the field and new technologies. The REF continues to make great strides in meeting the Army's strategic energy goals ("Taking Alternative Energy," 2013).

E. USMC RAPID ACQUISITION

The USMC does not have a dedicated rapid acquisition command. Instead, critical capability gaps are identified for correction by warfighter-submitted requests called urgent universal needs statements (UUNSs). The USMC has established the UUNS "as the single means to identify acute deficiencies in operational capability" (Flynn, 2008, p. 2).

The UUNS is an exceptional request from a combatant command–level Marine component commander for an additional warfighting capability critically needed by operating forces conducting combat or contingency operations. Failure to deliver the capability requested by the U-UNS is likely to result in the inability of units to

accomplish their missions or to risk increased probability of casualties and loss of life (Magnus, 2008, Enclosure 7, p. 1).

UUNSs, which have been identified by units “supporting, conducting, or awaiting imminent combat or specific contingency deployments” (Flynn, 2008, p. 3) are used to drive the urgent needs process (UNP).

The UNP is led by the DC CD&I, with the goal of rapidly fielding a solution to the capability gap identified in the UUNS (Flynn, 2008, p. 2). The Secretary of the Navy goal for the UNP is for the solution development team to provide a recommendation within 60 days of receipt of the UUNS and to provide the “best available solutions to mission-critical capability gaps … in less than 24 months” (Branch, 2012, p. 1-29). In order to meet this aggressive timeline, the UNP is designed to trade increased acquisition speed for additional risk incurred in terms of sustainment, maintenance, training, and other long-term considerations.

Once the validated UUNS has entered the UNP, the request is entered into the Virtual UUNS (VUUNS) system, an online collaboration tool that enables concurrent action from all of the involved stakeholders, rapid staffing, continuous oversight by senior leadership and a greatly reduced response time to provide the required capability (Flynn, 2008, pp. 2–3). Through the use of the VUUNS system, the DC CD&I gathers input from the stakeholders, ensures that the solution to the capability gap is not being addressed by other services’ urgent needs programs (e.g., Joint Urgent Operational Needs Statement, Urgent Operational Needs Statement), formulates a recommended course of action (COA), and then presents this COA to the Marine Requirements Oversight Counsel (MROC). The MROC then evaluates the COA and (assuming a positive decision) allocates resources to fund the capability for rapid deployment (Flynn, 2008, p. 3).

The final portion of the UNP is to transition the completed/fielded UUNS into an UNS. Transitioning the newly fielded technology into the deliberate acquisition cycle provides a thorough review of the capability and provides decision makers with the opportunity to evaluate it for further refinement, development and integration into the USMC as a POR.

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III. METHODOLOGY

The goal of this project is to conduct a comparative analysis of the ExFOB process with other acquisition processes, to measure the effectiveness of the ExFOB process and products toward reducing energy use, and to evaluate the value added to the Marine Corps. In order to assess the ExFOB's contribution toward a 50 percent reduction in Marine Corps expeditionary energy consumption, this project answers the following three questions:

1. What are the advantages and disadvantages of utilizing the ExFOB program within different acquisition processes?

2. What are the contributions of the ExFOB programs and process?

3. Is the ExFOB value added to the USMC?

The analysis of the ExFOB is performed in three phases. The first phase seeks to answer the research question: What are the advantages and disadvantages of utilizing the ExFOB program within different acquisition processes? Here, the ExFOB is analyzed from a "big picture" perspective as a process and how it functions within the acquisition process as a whole. Although the ExFOB is not an acquisition process in and of itself, in this phase it is analyzed within the acquisition process it utilizes. The ExFOB within the acquisition process is compared to other DOD acquisition processes such as rapid, REF, and traditional. All of the acquisition processes consist of three fundamental elements: requirements, resourcing, and acquisition (Chyma, 2010). The analysis looks broadly at these elements across the various acquisition processes to determine advantages and disadvantages of each.

The second phase is an analysis of the ExFOB energy programs to answer the research question: What are the contributions of the ExFOB programs and process? The ExFOB was involved in four programs which are now USMC PORs. The analysis comprises the following elements:

1. Description

- Requirement generation (if applicable)
- Cost
    - R&D and O&M funds spent during evaluation

2. Timeline

- Participation in initial ExFOB
- Dates dates/milestones through the ExFOB process
- Transition to USMC POR

3. Capability

- Performance of the system
- Incremental benefits over previous systems

4. Measure of Performance—Gallons Per Marine Per Day

- Establish consumption baseline assumption
- Analyze contribution of individual technology toward reducing fuel use

The third phase is value-added analysis. This phase serves to answer the research question: Is the ExFOB value added to the USMC? The analysis is founded in Knowledge Value Added (KVA) theory by Thomas Housel and Arthur Bell (Housel & Bell, 2001). KVA theory is used to formulate value centers or areas to be analyzed. The premise of the theory is that "processes within an organization should add value to the final product, and that variations in these processes are transformational and can be valued in the final product" (Middleton, 2006). The analysis uses value centers developed in the Naval Postgraduate School master's thesis *Assessing the Value of the Joint Rapid Acquisition Cell* by Middleton (2006). The value centers are predicated on a baseline that is established using data from Phase One, Phase Two, and the background section of our report. The baseline serves to show the processes before the ExFOB as well as existing processes. The following value centers are used (Middleton, 2006):

1. Speed
2. Budgetary Options
3. Streamlined Bureaucracy

4. Focus
5. Wider Portfolio Balance
6. Alignment with Acquisition Strategy
7. Impartiality
8. Life-cycle Costs
9. Feedback
10. Evolving Nature of War

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IV. ANALYSIS

The analysis of the ExFOB is performed in three phases. Phase one is a comparative process analysis to answer the research question: What are the advantages and disadvantages of utilizing the ExFOB program within different acquisition processes? Phase two is a contribution analysis to answer the research question: What are the contributions of the ExFOB programs and process? Finally, phase three is a value analysis to answer the research question: Is the ExFOB value added to the USMC? The answers to these questions enable an assessment of the ExFOB's contribution toward a 50 percent reduction in Marine Corps expeditionary energy consumption.

A. PHASE ONE: PROCESS ANALYSIS

Analysis of the ExFOB begins with understanding its purpose. As detailed in the background section, the USMC determined energy requirements and created the E2O office and the ExFOB to fulfill those requirements. The ExFOB is important to meeting these energy requirements because the CMC established a timeline in which to meet them. This analysis compares the ExFOB's role within an acquisition process in meeting the USMC requirements.

All acquisition processes, whether traditional or rapid, consist of three fundamental elements: requirements, resourcing, and acquisition (Chyma, 2010). The first part of the analysis examines how the ExFOB fits into DOD acquisition as a whole and specifically each of these fundamental elements. The analysis compares the ExFOB (within traditional acquisition) to USMC rapid acquisition (UUNS), traditional acquisition (without the ExFOB), and the REF within each of the three components. Facts and assumptions for this analysis are as follows:

- Scope is limited to COTS or non-developmental item (NDI) acquisition of existing or emerging technologies
- Data sets vary in size, and some are small
- Estimations are used when data are not available

1. Requirements Comparison

Regardless of the acquisition process, all of the processes have a requirements component. The various processes have different names for this component, but in general, the result is the same—a requirement is determined. The primary difference is in the process itself. As described in the various background sections, some of these processes are very involved and lengthy, while others are very streamlined and short. The processes in this component have varying time durations. In the following analysis, the various types of acquisition are examined side by side to better understand the differences and benefits within the processes.

a. Traditional Acquisition

Traditional acquisition is time-constrained by its deliberate process. The USMC has a set calendar schedule to align with the PPBE process because it reviews all USMC requirements during this deliberate review and validation process. Time duration for requirements determination is summarized in Table 2.

USMC and JCIDS process (Estimated 5-6 years*)		**Median Time in Days**
Initial generation and validation		
	CBA (Estimated 3-6 months)	120
	ICD USMC (October even yr - August odd year: 11 months)	330
	ICD JROC (2.5 months)	83
Subsequent reviews and validations		
	CDD USMC (October even yr - August odd year: 11 months)	330
	CDD JROC (2.5 months)	83
	CPD USMC (October even yr - August odd year: 11 months)	330
	CPD JROC (2.5 months)	83
*Total estimated time considers breaks between processes.		

Table 2. Traditional Acquisition Time Duration for Requirements Determination

b. USMC Rapid Acquisition—UUNS

USMC rapid acquisition uses UUNS, which is timely as it has truncated requirements generation and validation processes compared to traditional acquisition. A summary of time duration appears in Table 3.

UUNS	Median Time in Days
Requirement generation	103*
Requirement validation	90*
*Small sample size of 16 UUNS from (Under Secretary of Defense for Acquisition, Technology, & Logistics [USD(AT&L)], 2009, Figure 3).	

Table 3. UUNS Time Duration for Requirements Determination

c. REF

Similar to UUNS, the REF uses timely requirements generation and validation processes. The requirements are generated through the 10-line capability gap statement, which has all the same elements as a standard urgent operational need (UON) or UUNS. The validation process is expedited because the REF director analyzes and prioritizes requirements and then decides which requirements to fulfill and move to the materiel solution phase. The time duration is summarized in Table 4.

REF	Median Time in Days
Requirement generation	77*
Requirement validation	38*
Energy products only	90**
*REF data is included in all Army UONS data and the data is skewed smaller because equipment transfers were included (USD [AT&L], 2009, Figure 3).	
**Median days to validate only (W. Garland, personal communication, January 29, 2014).	

Table 4. REF Time Duration for Requirements Determination

d. ExFOB

Initial requirements determination was completed prior to the ExFOB using the traditional acquisition process—JCIDS. As noted in the background section, a CBA was

conducted and an ICD was produced. The primary difference is that this process does not go through the entire JCIDS process. From the ICD, the ExFOB does its work, which will be covered in the acquisition section, to solve the requirements gaps and a materiel solution. The solution is then re-inserted into the JCIDS process for review and validation (CPD) to get resourcing (PPBE). For the purposes of this analysis, the CBA and ICD time durations were exempted from the ExFOB timeline because it was a one-time event for all off the ExFOBs and completed years ago. The time duration is summarized in Table 5.

ExFOB ICW truncated JCIDS process (4 years)		Median Time in Days
Initial generation and validation		Not included
Subsequent reviews and validations		
	CDD USMC (October even yr - August odd year: 11 months)	330
	CDD JROC (2.5 months)	83
	CPD USMC (October even yr - August odd year: 11 months)	330
	CPD JROC (2.5 months)	83
ExFOB ICW UUNS		
Requirement generation		103*
Requirement validation		90*
*Data not available for UUNS in conjunction with ExFOB but it is estimated to be analogous to other UUNS data from (USD [AT&L], 2009).		

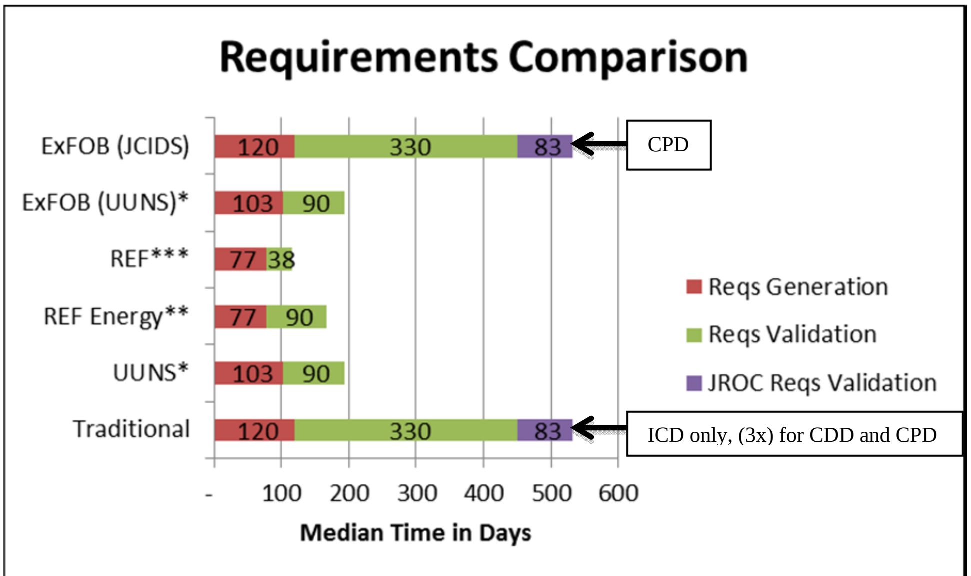
Table 5. Time Duration of ExFOB In Conjunction With (ICW) an Acquisition Process for Requirements Determination

e. Summary

Requirements determination using the JCIDS process is very lengthy as easily seen in Figure 15. The advantage of the ExFOB is the ICD was developed and it can continue to determine materiel solutions. However, the requirements process is dynamic, and technology changes rapidly. In general, requirements review and validation is an annual event for the USMC. From the ExFOB, the materiel solution re-enters the JCIDS process.

Requirements determination using rapid acquisition is short duration. The USMC process using UUNS or the REF both have very short generation and validation times.

For war time needs, this is very important, but it is also important in cases where a capability is needed faster than the traditional acquisition process. The ExFOB in conjunction with UUNS and REF energy initiatives are both good examples of how quickly requirements can be determined. From the ExFOB, the materiel solution goes straight to acquisition using an UUNS. The requirements comparison is depicted in Figure 13.



* UUNS data from (USD [AT&L], 2009, Figure 3).
** Data not available for REF energy requirements generation but it is estimated to be analogous to other REF data from (USD [AT&L], 2009).
*** REF numbers are skewed lower because it is combined with Army UON and includes redistribution of inventory (USD [AT&L], 2009).

Figure 13. Requirements Generation and Validation Comparison in Median Days

2. Resourcing Comparison

Regardless of the acquisition process, all of the acquisition processes have a resourcing component. The various processes have different methods and sources of funding, which can be limiting. Since Congress controls the purse strings, there are only certain pots of money authorized for resourcing. This component is also deliberate in certain acquisition processes, which means that it can be time-consuming as well. Conversely, resourcing can be very fast under other processes. Therefore, side-by-side

analysis of the resourcing time duration involved in various types of acquisition helps to better understand the differences as well as costs and benefits. This analysis specifically examines the time duration involved to obtain funds in order to field a capability.

a. Traditional Acquisition

As seen in the requirements section, this process is deliberate so it aligns with the PPBE process, which is also deliberate. The POM is submitted in the even years, which is why the requirements are reviewed and validated in the odd years. Time duration is summarized in Table 6.

USMC and PPBE Process	Time Duration
JCIDS: Need identified and approved	2 years
Requirement approval to program initiation	2 years
Total time until funding to initiate program	4 years

Table 6. Traditional Acquisition Time Duration for Resourcing

b. USMC Rapid Acquisition—UUNS

UUNS resourcing occurs quickly because it uses funds by exception. The most common method is congressional supplemental appropriations and recently overseas contingency operation (OCO) funds. The second method is to reprogram funds of approved programs. Reprogramming funds can be done at the USMC level as long as the dollar amount is under a certain limit. If it is over the limit, then it needs congressional approval, which takes more time. The time duration is summarized in Table 7.

UUNS	Median Time in Days
OCO (Estimated 15-30 days)	14
Congressional supplemental appropriation (Estimated 3-6 months)	120
Reprogramming funds from approved programs (0-3 months)	45

Table 7. UUNS Time Duration for Resourcing

c. REF

The REF is similar to UUNS in resourcing but also has additional means. It uses reprogrammed funding and supplemental appropriations for funding. However, the primary source of funding for the REF is a baseline budget, which it uses for anticipated needs. Time duration is summarized in Table 8.

REF	Median Time in Days
Baseline budget (Estimated a few days for approval)	3
Congressional supplemental appropriation (Estimated 3-6 months)	120
Reprogramming funds from approved programs (0-3 months)	45

Table 8. REF Time Duration for Resourcing

d. ExFOB

Similar to the REF, the ExFOB has a baseline budget which is programmed (PPBE). The budget consists of Operations and Maintenance (O&M) and Research, Development, Test and Evaluation (RDT&E) money. Although the baseline budget is programmed and readily available, the ExFOB does not use it to field items. Funding for fielding comes from two different sources and is handled by Marine Corps Systems Command (MCSC). When an item is programmed, it uses the traditional process and takes two years to receive funding. The ExFOB can also respond to an UUNS in which case the respective funding is available. Time duration is summarized in Table 9.

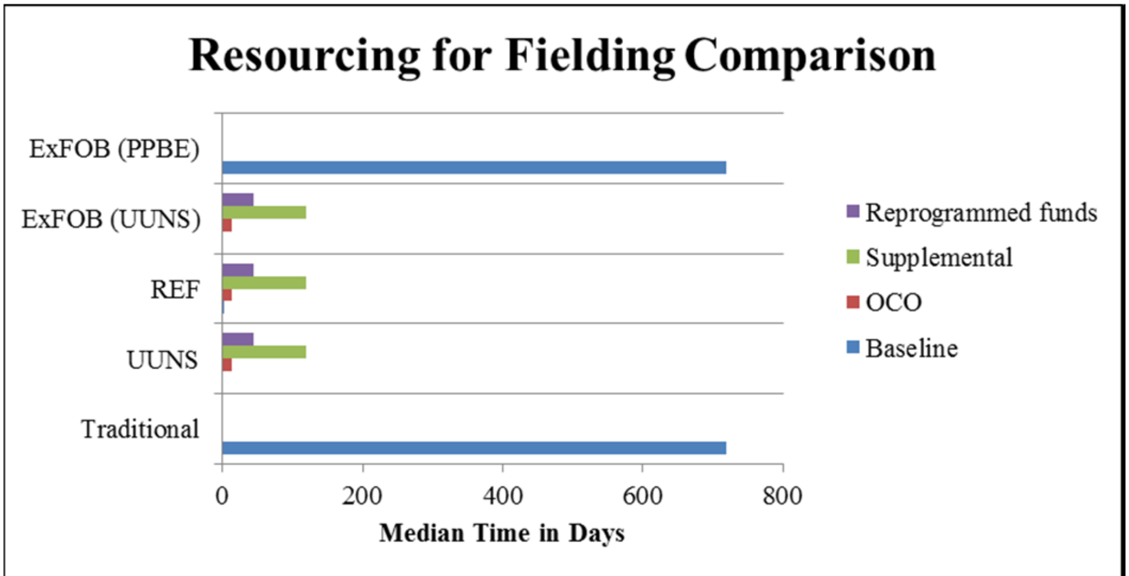
ExFOB ICW an acquisition process	Median Time in Days
Baseline budget is for RDT&E only and available	0
ICW PPBE (Estimated 2 years)	720
ICW UUNS (Estimated 14-120 days)	45

Table 9. Time Duration of ExFOB ICW an Acquisition Process for Resourcing

e. Summary

Resourcing is distinctly different across the various acquisition processes. The ExFOB is resourced only for RDT&E, and a materiel solution must be programmed using PPBE to be procured. The PPBE can be lengthy depending on when it enters the POM cycle.

The rapid acquisition resourcing is much shorter regardless of the funding source. Since funds are essentially available for acquisition, the materiel solution is procured once the ExFOB is complete. The advantage of the REF is it is authorized to procure and is resourced accordingly. The resourcing for fielding comparison is depicted in Figure 14.



Note: ExFOB is not resourced for fielding but is used ICW with an acquisition process.

Figure 14. Resourcing Comparison of Acquisition Processes

3. Acquisition Comparison

Regardless of the acquisition process, all of the processes have an acquisition component. The primary difference is in the process itself. As described in the various background sections, some of these processes are very involved and lengthy while others are streamlined and short. In the following analysis, the various types of acquisition are

examined side-by-side to better understand the differences as well as costs and benefits in the processes. The analysis specifically focuses on the time duration involved to have an initial operating capability (IOC) after the requirement is validated and resourced.

a. Traditional Acquisition

Acquisition does not take place until funding is available. As mentioned previously in the resourcing section, it takes two to four years for approval and funding. The funding starts the development phase, which is minimal because the acquisition is for NDI or modified COTS. Items are purchased for initial fielding and test and evaluation. Based on the tests, items are modified if needed until it meets USMC's requirements. Then items are purchased for deployment. See summary of time duration in Table 10.

USMC DAS	Median Time in Days
RDT&E	270
Initial fielding or IOC (Estimated 3-12 months)	365
Full rate production of full operational capability (Estimated 3-12 months)	365
Total (From RDT&E to IOC)	635

Table 10. Traditional Acquisition Time Duration for Procurement

b. USMC Rapid Acquisition—UUNS

UUNS is very fast in acquiring capabilities for warfighters. This process is not hindered by funding and has a streamlined approval and validation process. Summary of the time duration is given in Table 11.

UUNS	Median Time in Days
From RDT&E to IOC	142
Note: Data from (USD [AT&L], 2009).	

Table 11. UUNS Time Duration for Procurement

c. REF

The REF is similarly very fast in acquiring capabilities. Besides not being hindered by funding and the approval and validation processes, the REF equips rather than fields. Equipping means the capability can be acquired at a lower standard, which is often faster. Summary of the time duration appears in Table 12.

REF	Median Time in Days
From RDT&E to IOC	103*
Advertised 90-180 days (Figure 6)	120
Expeditionary energy materiel solutions only	300**
*REF data is included in all Army UONS and the data is skewed smaller because equipment transfers were included (USD [AT&L], 2009, Figure 3).	
**Data from (W. Garland, personal communication, January 29, 2014).	

Table 12. REF Time Duration for Procurement

d. ExFOB

The ExFOB by design was established to test and evaluate COTS energy items. Through the ExFOB process, operational testing is streamlined, and modifications are made along the way in order to meet USMC requirements. The acquisition path follows the respective resourcing path and is handled by MCSC. If the item is programmed, it uses the traditional process and enters DAS. If it uses UUNS, funding is readily available, and acquisition starts quickly. Time duration is summarized in Table 13.

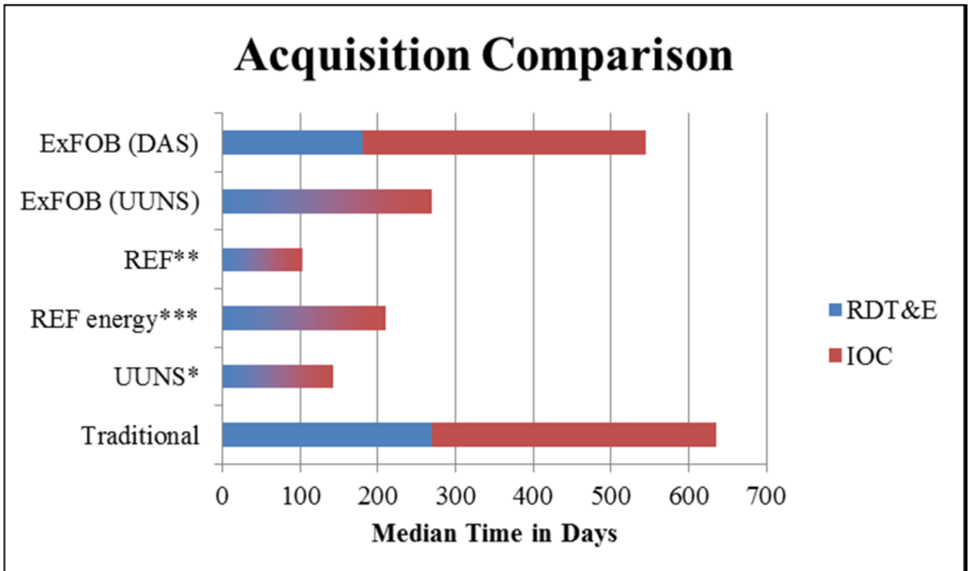
ExFOB	Median Time in Days
RDT&E (semi-annual events)	180
ICW DAS (Estimated 1-2 years)	365
ICW UUNS (From RDT&E to IOC)	270
Total time duration ExFOB ICW DAS	545

Table 13. Time Duration of ExFOB ICW an Acquisition Process for Procurement

e. Summary

The ExFOB has a streamlined RDT&E process. Compared to traditional acquisition, it is estimated to be much faster on average. Regardless of using the traditional or rapid acquisition process, the ExFOB's role is the same. The time duration to field a product or achieve IOC under the different acquisition processes is significant.

The ExFOB in conjunction with UUNS is very similar to REF energy in time duration. REF is typically much faster in equipping on average, but the energy products seemed to be more deliberate. The UUNS process on average is also much faster and highlights the difference between the ExFOB's deliberate RDT&E and wartime needs. The acquisition comparison is depicted in Figure 15.



* UUNS data from (USD [AT&L], 2009, Figure 3).
** REF numbers are skewed lower because of redistribution of inventory (USD [AT&L], 2009).
*** REF energy data from (W. Garland, personal communication, January 29, 2014).

Figure 15. Acquisition Comparison to Reach IOC

4. Comparing the Whole

The individual components above highlight some of the key differences between the various acquisition systems. To better illustrate the differences of the processes, Figure 16 compares all processes and components together.

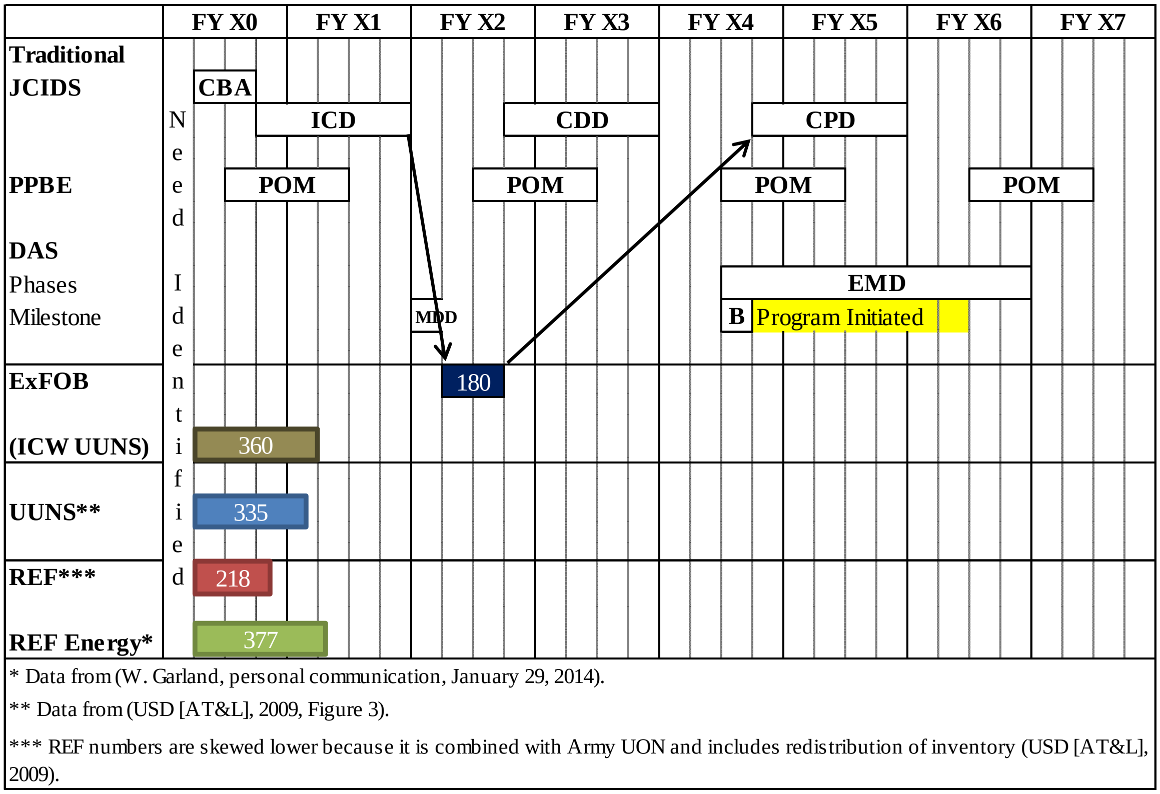


Figure 16. Comparison of Acquisition Processes from Identified Need to Initial Fielding or IOC (after Chyma, 2010, p. 13)

The ExFOB's benefit in the acquisition of USMC energy requirements can be easily seen in Figure 18. The ExFOB accelerates the R&D process and injects the COTS item identified for acquisition into the USMC traditional acquisition process. By doing this, nearly two to three years are eliminated from the traditional process. Again, the traditional process can take about five to six years from the time a need is identified until a materiel solution is fielded (Chyma, 2010). This deliberate process makes sense since there is no urgency for the requirement. The ExFOB, however, accelerates the traditional

acquisition process, which is needed because there are many capability gaps to fill by the 2025 deadline.

The ExFOB process in conjunction with traditional acquisition does not come close to the UUNS or the REF processes in terms of time duration with median days of 335 and 218, respectively. Only considering the REF energy projects, it is still only 377 median days. The ExFOB process, from the start of an ExFOB to the fielding of a capability, can take two to three years. Another difference between the two is the ExFOB is a semiannual event and the REF is not on a deliberate schedule. The distinct differences are attributed to the REF being a rapid acquisition organization and the ExFOB not being one and therefore having to work within the traditional acquisition process. The UUNS follows a rapid acquisition process as well and is used occasionally for USMC energy requirements. The ExFOB's role using the UUNS process appears to be the same as using the traditional process in that it determines the materiel solution for MCSC. MCSC can then rapidly acquire the identified materiel solution using UUNS resourcing. The four PORs were acquired using UUNS vice traditional acquisition and the time duration was 360 median days. The ExFOB time duration does not include requirements generation time but does add 90 days for validation. This process is nearly the same time duration as the REF energy initiatives at 377 days.

5. ExFOB Versus REF Case Study: 3kW Hybrid Systems

Solar Stik, a St. Augustine, FL, company, manufactures a power system that is comprised of rigid solar panels or a wind turbine, the Wind Stik, and also a combination generation set of solar panel and wind turbine generation. This system is portable and can be quickly set up in proximity to power users. The Solar Stik system is able to supply power to a variety of applications including lights, computers, and cooling. Solar Stik manages the power generated by its system via the Power Paks power management and storage equipment. The systems come in multiple configurations that can store 500 or 1000-watt-hours of power. The units manage and monitor the solar charge, batteries, power outputs, both AC and DC, and system circuitry (Kauchak, 2011).

Both the U.S. Army and the USMC have a need for systems that can provide 3kW of power, and both sought out a hybrid system that would be suitable for their use. Recently, both organizations evaluated a hybrid system produced in part by Solar Stik. The unit is composed of a solar panel set mounted either to a trailer or on a stand, combined with a generator. It is unclear from reports furnished if both the REF and the ExFOB used the exact equipment combinations, but for this analysis, the requirement for 3kW of hybrid power was identical. According to the manufacturer, the Solar Stik hybrid system will manage power generated from its solar panels and store excess energy in a battery bank. When the solar energy generation does not meet the power needs and the batteries are running low, the generator will start and charge the batteries. This configuration can produce two-thirds fuel savings over the traditional power supply (Canaday, 2012). Solar Stik systems allow power to be stored and instantly available to the power application versus a traditional generator system that is constantly generating power at peak power levels and meeting the instant power demands of the system. The traditional system creates a large amount of unused and non-stored power. A 2011 USMC study at PB Boldak found that a hybrid power system could reduce generator runtime by 80 percent and decrease fuel consumption by 55 percent. These tests were carried out on a 10kW system, but results for lower power demands will be similar and the USMC reported that at loads below 6kW the hybrid system would be very effective (USMC E2O, 2013). The USMC results are further backed up by the Army REF's Village Stability Platform Lam, an isolated base on a mountainside near Kandahar, Afghanistan. The REF made measurements before and after adapting its facility to a hybrid system for Lam. The hybrid initiative reduced the number of generators required for their outpost from five to three. By reducing the number of operating generators, the outpost decreased their daily fuel consumption by 120 gal/day, as well as reducing the base's logistical needs. The hybrid system allows the base to go further without resupply, thus increasing its warfighting capability (W. Garland, personal communication, January 29, 2014).

a. *REF Solar Stik 380/400*

The REF 3kW hybrid energy system used the Solar Stik technology, as well as some portion of their system being supplied by Alion Science of Mt. Arlington, New Jersey. The Army's objective was to reduce fuel consumption while storing excess energy generated. The 3kW hybrid system would save up to 50 percent usage and decrease required maintenance on existing generators (W. Garland, personal communication, January 29, 2014). The REF evaluated the Solar Stik 380/400 (see Figure 17) in September 2012; by April 2013, the REF had purchased 18 units and sent them out for use at a cost of $1.46 million. The systems were sent to units supporting OEF, U.S. Southern Command, and U.S. Africa Command (W. Garland, personal communication, January 29, 2014).

Figure 17. Solar Stik (from W. Garland, personal communication, January 29, 2014)

b. *ExFOB 3kW Hybrid System*

At ExFOB 2013, the USMC demonstrated two 3kW hybrid systems. The Solar Stik MIL Series 3kW trailer with the Earl Energy 3kW FlexGen system (see Figure 18). The Solar Stik showed at reduction of 50 percent fuel and 56 percent runtime over the standard 3kW Tactical Quiet Generator (TQG). The Earl Energy 3kW FlexGen system

reduced fuel consumption by 52 percetn and runtime by 66 percnt. The systems met with initial USMC approval, and subsequent agreements for follow-up were made. The USMC will be performing further evaluation of the system at NSWC Carderock during 2014. The cost to the ExFOB budget for the demonstration was $265,000 in RDT&E (K. Hanson, personal communication, December 16, 2013).

Figure 18. USMC Solar Stik MIL Series 3kW Trailer and Earl Energy 3kW FlexGen (from K. Hanson, personal communication, December 16, 2013)

c. Analysis

The 3kW hybrid system is the best example of an identical system moving through both the REF and the ExFOB processes. The nature of the two organizations becomes clear through their spending data. The REF seeks to provide answers in the short term to meet the needs of Army units now; a quick field check of a product to ensure it will meet minimum requirements is all that is required to get it to the field. Follow-on procurement may be an option for the Army if the system proves capable and useful, but the REF excels at quick solutions. The USMC uses the ExFOB to evaluate materiel solutions and contribute to achieving the USMC fuel savings objectives. The ExFOB takes a long view approach to energy solutions and is not interested in immediate needs of the USMC. ExFOB can patiently determine which material solutions are in the best interest of the USMC to meet the USMC Commandant’s objectives.

B. PHASE TWO: CONTRIBUTION ANALYSIS

The ExFOB program's contribution toward reducing expeditionary energy use is analyzed in terms of time saved through an accelerated acquisition process and the fuel-savings generated by the individual technologies recommended for procurement.

1. GREENS

Although the Ground Renewable Expeditionary Energy Network System (GREENS) (see Figure 19) program started as an answer to the relatively small-scale problem of providing power for a remote camera system, the requirements developed by the ExFOB evolved it into a more capable system. GREENS Gen 1 has the capacity to provide 300W, 24V continuous power (1000W peak) without the use of any fuel, and the Gen 2 is able to provide a maximum of 5000W and take advantage of a broader spectrum of sunlight (UEC Electronics, n.d.). This capability has enabled the Marines to reduce the fuel consumed to generate electricity at forward operating bases. These fuel savings can be translated into a reduced requirement for the number and size of supply convoys (which, in turn, reduces casualties suffered from ambushes and IEDs against those vulnerable convoys), or into increased operational capability with the same quantity of fuel delivered to the forward location in the form of additional fuel for combat/utility vehicle use (MRAP, etc.).

Figure 19. GREENS Units (from Marine Corps Systems Command [MCSC], 2011)

a. *Timeline*

The timeline outlined below demonstrates the aggressive schedule the ExFOB maintained once they had access to the technology.

- 2008—Forward-deployed Marines identified a critical requirement and submit a UONS to power a rooftop-mounted Ground-Based Operational Surveillance System (G-BOSS) without using a generator (the ground-level generator was loud, decreasing the situational awareness of the Marines, and was also prone to tampering/pilfering by the local population).
- July 2009–March 2010—The request was forwarded to Naval Surface Warfare Center (NSWC) Carderock, to develop a solution using COTS equipment and conduct limited test and evaluation (K. Hanson, personal communication, December 16, 2013).
- March 2010—Prototype GREENS sent to the first ExFOB (2010-1) for evaluation against commercially available options.

- May–June 2010—Prototype GREENS participate in Exercise African Lion as part of an early-stage field evaluation.
- October 2010—Seven units are produced by NSWC Carderock and deployed with India 3rd Battalion/5th Regiment to Afghanistan for further field evaluation.
- March 2011—Statement of need issued (USMC E2O, 2013).
- April 2011—UEC Electronics awarded an $11 million production contract for 270 GREENS systems (UEC Electronics, 2012).
- July 2012—UEC Electronics awarded a $40 million production contract for 1,000 additional GREENS systems (UEC Electronics, 2012).

b. *Measure of Performance*

The acquisition of the GREENS is evaluated in terms of both the contributions of the individual system and the ExFOB process toward reducing expeditionary energy use.

(1) Contribution of GREENS. The GREENS system is providing considerable reductions in fuel required across the Marine Corps. According to a case study performed by UEC, GREENS units are each saving roughly 27 gallons of fuel per day, and as a result, their deployment across 100 patrol bases is saving the Marine Corps roughly $26 million per year in fuel costs. Assuming one GREENS unit per patrol base, we multiplied the number of gallons of fuel saved per day per GREENS by 365 days and then multiplied that by the number of deployed GREENS (100 units) to find that those GREENS are saving approximately 985,000 gallons of fuel per year (see Equation 1).

$$\frac{\text{27 gallons of fuel (saved per GREENS)}}{\text{day}} \times \frac{\text{365 days}}{\text{year}} \times \text{100 GREENS} = \frac{\text{985,000 gal of fuel (saved)}}{\text{year}} \quad (1)$$

Working backward from the Marine Corps study finding of saving $26 million per year across those same 100 patrol bases, we find a fuel cost of $26.40 per gallon (see Equation 2).

$$\frac{\$26{,}000{,}000 \times \text{year}}{985{,}000 \text{ gal} \times \text{year}} = \frac{\$26.40}{\text{gallon}} \quad (2)$$

Initially, the idea of $26.40/gallon seems high for fuel. However, once the costs incurred to actually get that fuel from the pump (at roughly $3/gallon) to the FOB are included, this is easier to believe. In fact, there are estimates ranging from $200 to $400 per gallon for a fully burdened cost of fuel delivered in-theater (Tiron, 2009). The

estimate of $400 per gallon came of the requirement to use helicopters to deliver fuel to some SOF bases, which were inaccessible by road, and serves as a good estimate of what it could cost to deliver fuel in other areas where the roads are unreliable, damaged, or destroyed. Although the war in Afghanistan is winding down, as the United States' first responders, the Marine Corps will continue to operate ahead of a well-established logistics trail in austere and remote environments (i.e., while conducting humanitarian assistance and disaster relief [HADR] missions in the aftermath of a natural disaster). Figure 20 shows how the savings (in dollars) would be affected by the location the fuel is delivered to, based on that range of fuel prices and assuming 100 GREENS units in operation. This wide range of savings demonstrates the importance of the GREENS capability at the most remote locations.

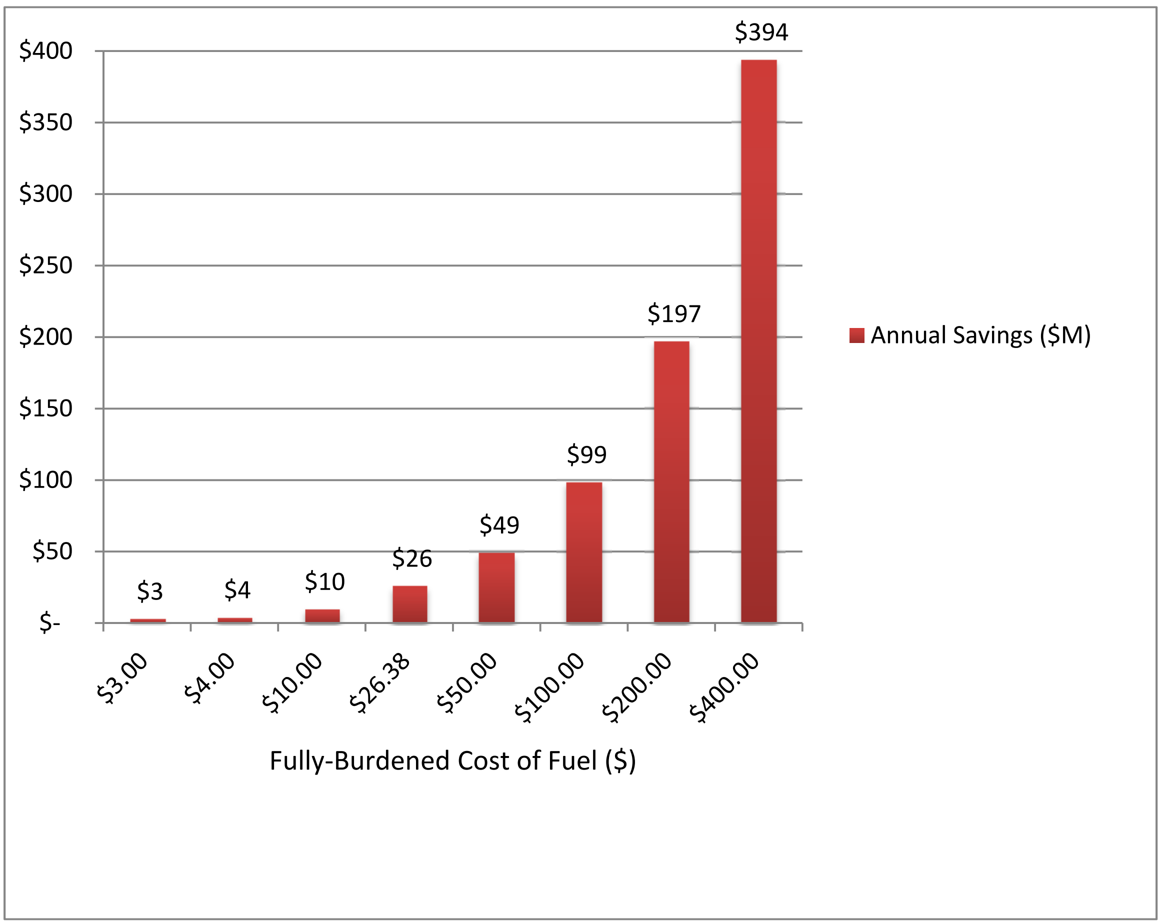


Figure 20. Annual Savings Versus Fully-Burdened Fuel Cost

Assuming current levels of fielding of GREENS (through continued expeditionary operations, CONUS-based training missions during home-cycle, HADR assistance, or any of the other missions assigned to the USMC), the Marines will continue to save \$26 million in fuel annually. Compared to the program purchase cost of \$51 million, \$500,000 O&M funds, and \$350,000 R&D funds, this represents a rapid return on investment.

(2) Contribution of the ExFOB Process. The biggest savings come from the continuing operation of the GREENS systems. What must also be considered when looking at the ExFOB program is the additional capability generated by the ExFOB process. By taking 11 months off the minimum COTS timeline (which is typically at least two years) to procure and deploy the same 100 GREENS units, the ExFOB process saved the Marine Corps \$23.8 million in fuel costs.

$$\frac{\$26\text{M savings}}{\text{year}} \times \frac{11\text{ months saved}}{12\text{ months per year}} = \$23.8\text{M} \qquad (3)$$

Translated through the Marine’s assumption of \$26.40/gallon, this savings equals roughly 903,000 gallons of saved fuel. As an added benefit, by removing the need to deliver that fuel to the FOBs, the ExFOB has indirectly reduced the danger faced by Marines escorting fuel convoys. Here is where we see the true benefit of the ExFOB; the process enables them to rapidly evaluate a new capability, match the capability to an identified and validated requirement, and field that product. The speed at which this process is accomplished benefits both the end users and the Marine Corps as a whole by enabling them to do more with the same amount of resources.

2. SPACES and SPACES II

The need for a portable solar charging and power device became obvious to the USMC shortly after OIF commenced. Through an UUNS the requirement for Solar Portable Alternative Communications Energy System (SPACES) was created. Troops dispersed in rugged terrain far from logistic support and a base of operations needed a means to operate their radios and charge batteries for communication devices. Solar panels, which are ruggedized and attached to a fold out cover, are the primary means of powering the charging system. If adequate solar power is not available, the system has

multiple power inputs, including various batteries and fuel cells, or a North Atlantic Treaty Organization vehicle adapter. The entire unit weighs 2.6 pounds (not including the batteries being charged). It is a plug and play system that required no adjustments; once connected SPACES provides 12 to 32 VDC, and up to 320W maximum (there are two output connectors that allow 160W each). The system is 96% efficient and can charge a standard LiIon battery in three hours. The system's main use is to charge BB-2590 tactical batteries, but the power outlet can supply power directly to AN/PRC-148, -152 and -153 radios (K. Hanson, personal communication, December 16, 2013; Iris Technology Corporation, 2010). A SPACES system is available for purchase via the General Services Administration (GSA) website for $6,737.51 (General Services Administration [GSA], 2014).

Figure 21. SPACES unit (from K. Hanson, personal communication, December 16, 2013)

a. Timeline

- 2002—Marine Corps Systems Command Expeditionary Power Systems–PMM-153 experiments with a portable solar charging system called SPACES.
- April 2004—Requirement signed seeking solar solution that would power equipment similar to batteries, without modification.
- September 2004—PMM-153 recognizes solar may be a solution to power supply needs for fielded units.
- 2009—434 SPACES units produced.
- March 2010—SPACES demonstrated at ExFOB 2010-1 MCB Quantico, VA.
- 2010—SPACES initial operational capability, over 1,000 units produced by manufacturer Iris Technology Corporation.
- 2011—SPACES II request for information.
- 2012—SPACES II request for proposal.
- 2014—SPACES II initial operational capability.
- 2016—SPACES II full operational capability (K. Hanson, personal communication, December 16, 2013; Iris Technology Corporation, 2010; Martin, 2004).

b. Measure of Performance

The acquisition of the SPACES is evaluated in terms of both the contributions of the individual system and the ExFOB process toward reducing expeditionary energy use.

(1) Contribution of SPACES system. The SPACES system has provided a twofold capability: First, Marines on patrol are not required to carry replacement batteries for their equipment (which can save approximately 900 lbs. for a 14-day mission); second, the SPACES system serves as a source of supplemental electricity when the Marines are in camp between missions (MCSC, 2012).

The ability to charge their batteries on patrol, while not directly saving fuel, has tremendous second-order savings for the Marines in the form of reduced logistics support. The Marines have determined that for every gallon of water or fuel delivered to the front lines, seven gallons of fuel are used to get it there (Vavrin, 2010). Assuming the

averaged weight of the water and diesel fuel is 7.5lbs/gal, this means that every pound of supplies requires approximately .93 gal of fuel to deliver it to an FOB. If Marines at each of the 100 FOBs in Afghanistan conduct two 14-day patrols each month, Equation 4 shows that there could be more than two million gallons of fuel saved each year.

$$\frac{900\text{ lbs (saved)}}{\text{patrol}} \times \frac{2\text{ patrols}}{\text{FOB*month}} \times \frac{0.93\text{ gal}}{\text{lb (delivered)}} \times 100\text{ FOBs} \times \frac{12\text{ months}}{\text{year}} = 2{,}008{,}800\ {}^{\text{gal}}\!/_{\text{year}}\text{(saved)} \tag{4}$$

In addition to reducing the pounds of batteries required at FOBs, SPACES are having an unintended benefit: Marines are able to use them in camp to power military equipment, as well as personal electronics. In spite of being incredibly wasteful, "[t]he reality is Marines are turning on a three-to-six kilowatt generator so they can charge their iPod" (MCSC, 2012). The Marines' 3kW generator uses 0.5 gallons per hour (MCSC, 2011), so even if all the Marines got together to charge their personal gear over the course of an hour, more than 18,000 gallons of fuel could be saved each year by not using 3kW generators to power 5W iPods (see Equation 5).

$$\frac{0.5\text{ gallons}}{\text{hour}} \times \frac{1\text{ hour use}}{\text{day}} \times 100\text{ FOBs} \times \frac{365\text{ days}}{\text{year}} = 18{,}250\ {}^{\text{gal}}\!/_{\text{year}}\text{ (saved)} \tag{5}$$

What truly highlights the savings SPACES generate in basecamp is factoring in the seven gallons of fuel required just to deliver each gallon of generator fuel, boosting the initial gains by a factor of eight for net savings of 146,000 gallons per year and pushing the total annual savings to 2,154,800 gallons of fuel per year.

(2) Contribution of the ExFOB. The ExFOB's process enabled the SPACES to go from an initial demonstration in March of 2010 to IOC in one year, saving an entire year off the usual 24-month COTS purchase timeline. This translates to a one-time savings of more than two million gallons of fuel.

3. LED Tent Lighting System

Increased efficiency of lighting is an obvious choice to reduce a power and fuel demand for an FOB, every watt that can be saved is less power required. If the power supply is JP-8, then that power saving equates to less demand for fuel. If the fuel is solar, improved efficiency of lighting increases the longevity of stored power. At ExFOB 2010-

1, in March 2010, the Jameson LLC from Clover, South Carolina, demonstrated a line of LED lights (see Figure 22) that could be set up in strings, producing enough light to fill the necessary tent space. This was a true off-the-shelf solution. The LED lights were capable of operating at multiple voltages (110–230 VAC), and had an expected lifespan of 50,000 hours. The light had three operating modes (blackout, low, high), which has a power draw range of 14–27W. The LED lighting system would draw 25–60% over traditional lighting systems in use by the USMC. Initially the USMC bought 1,760 light kits and immediately had them shipped to Afghanistan for use and evaluation. The cost of the initial R&D cost to the ExFOB was $136,000 (Jameson, LLC, 2014). Currently the USMC is evaluating a LED lighting system produced by Techshot Lighting of Floyds Knobs, IN. The system is similar, promising 30–60 percent reduction in power requirements. The Techshot system is a hanging light system where the LED lights hang down from a power cord instead of being strung up from the ceiling for support. The Techshot light also claims to offer "better" light and a 50,000–100,000 hour life cycle. It has only two modes, normal and blackout, that draw 3–10W of power. The new lights meet MIL-STD compliance to water resistance, EMI and thermal operating ranges and cargo vibration (Techshot Lighting, LLC, 2014).

Figure 22. LED Lights (from K. Hanson, personal communication, December 16, 2013)

a. Timeline

- March 2010—ExFOB 2010-1 MCB Quantico, VA SPACES demonstrated.
- November 2010—Urgent Statement of Need signed.
- December 2010—Acquisition Decision Memorandum signed (K. Hanson, personal communication, December 16, 2013; MCSC, 2014a).

b. Measure of Performance

Evaluating the acquisition of the LED lights in terms of both the contributions of the individual system and the ExFOB process toward reducing expeditionary energy use.

(1) Contribution of LED Lights. For planning expeditionary facilities for a Marine Expeditionary Brigade, a key point is the amount of housing that will be required for the 17,000 Marines deployed to the field. Using FM 3.34-400 as a guideline, there will need to be 1,288,600 sq. ft. of tents to adequately house everyone (U.S Army HQ, 2008). In order to meet the MIL-STD requirement for indoor lighting, Techshot (which manufactures the LED lights used by the Marines) recommends using one LED light per 25 sq. ft. of shelter space. This recommendation would require 51,544 lights for the MEB shelters. Assuming these shelter lights are on in normal mode (10W, 1000 lumens), comparing the power requirement for the LED lights vs. incandescent bulbs (60W, 840 lumens), Equations 6 and 7 demonstrate that the LED lights use 2,629 kW less than incandescent bulbs.

$$\text{LED Lights: } 51{,}544 \text{ lights} \times \frac{10\text{W}}{\text{light}} = 515{,}440 \text{ W} = 515.4\text{kW} \tag{6}$$

$$\text{Incandescent Lights: } 51{,}544 \text{ lights} \times \frac{60\text{W}}{\text{light}} = 3{,}092{,}640 \text{ W} = 3{,}093 \text{ kW} \tag{7}$$

Making this swap to LED lights enables the Marines to remove 26 100kW generators off the battlefield and save nearly 1.8 million gallons of fuel for those generators (see Equation 8). Considering the second order savings of 7 gallons of fuel

used to deliver each gallon of generator fuel, to total rises to 14.3 million gallons of saved fuel each year.

$$26 \text{ generators } \times \frac{7.85 \text{ gallons of fuel}}{\text{hour}} \times \frac{24 \text{ hours}}{\text{day}} \times \frac{365 \text{ days}}{\text{year}} = 1{,}787{,}916 \ {}^{\text{gal}}\!/_{\text{year}} \text{(saved)} \tag{8}$$

(2) Contribution of the ExFOB. The LED lighting system was evaluated at ExFOB 2010-1 in March of 2010 and purchased using an acquisition decision memorandum (ADM) in December of 2010: a process requiring nine months in total. The speed of the ExFOB evaluation process meant that the LED lights were procured 15 months faster than the COTS average. Assuming the same use rate from above, this reduced acquisition timeline saved the Marine Corps more than 2.2 million gallons of fuel that would have been wasted by older systems being used while waiting for a slower acquisition process.

4. Insulating Liner

An obvious improvement that could reduce power demands on USMC expeditionary bases was heating and cooling requirements. By their nature, tents are not efficient at regulating temperatures and with the need for computers on the battlefield the importance of temperature is not only a comfort factor for troops, but a necessity for the electronics. At ExFOB 2010-1, HDT Global (a company producing expeditionary shelters for the Marine Corps) demonstrated a tent liner (see Figure 23) that could be put in between the outer and inner layers of tactical USMC tents. The layer was lightweight and served both heating and cooling needs (MCSC, 2014b). The barrier would maintain desired temperatures, holding in heat in low temperature environments and holding in cool air and reflecting heat when external temperatures are high. The insulating liner effectively doubled the insulating capacity of the tents increasing their "R" value from two (R2) to four (R4). The radiant barrier liner meets MIL-STD requirements for flame resistance and various other requirements (K. Hanson, personal communication, December 16, 2013). The USMC bought 800 of the tent liners without any RDT&E cost to the ExFOB (K. Hanson, personal communication, December 16, 2013).

Figure 23. Shelter Liners (from K. Hanson, personal communication, December 16, 2013)

a. Timeline

- March 2010—ExFOB 2010-1 MCB Quantico, VA, SPACES demonstrated.
- September 2010—Urgent Statement of Need signed.
- October 2010—Acquisition Decision Memorandum signed (K. Hanson, personal communication, December 16, 2013; MCSC, 2014b)

b. Measure of Performance

Evaluating the acquisition of the Shelter Liners in terms of both the contributions of the individual system and the ExFOB process toward reducing expeditionary energy use.

(1) Contribution of Shelter Liners. During 2009, in Afghanistan Marine Expeditionary Brigade-Afghanistan (MEB-A) was using 28,500 gallons of fuel per day to

generate electricity (Marine Corps Warfighting Lab [MCWL], 2010). Assuming this electricity is being produced by 100kW generators (each using 7.85 gal/hr of fuel), then (as illustrated in Equation 9) there is 15.1MW of electricity being generated around the clock.

$$\frac{28{,}500 \text{ gallons}}{\text{day}} \times \frac{\text{hr}}{7.85 \text{ gal}} \times \frac{\text{day}}{24 \text{ hr}} = 151 \text{ 100kW generators} \tag{9}$$

In a 2009 study, the Marines found that approximately 75 percent of the electricity generated was being used to power HVAC systems in inefficient structures, such as the tents that make up most FOBs (Vavrin, 2010). This means that roughly 11.3MW of the total generated power is used for air conditioning.

The total heat transfer into or out of a structure (which must be managed by an HVAC system) is calculated using the formula in Equation 10, where Q is the heat transfer, A is the surface area of the structure, R is the insulation value, ΔT is the temperature difference across the structure and t is time (Ristinen & Kraushaar, 2006).

$$Q = \frac{A}{R}(\Delta T)(t) \tag{10}$$

The shelter liners evaluated by the ExFOB increase the R-value of expeditionary shelters from 2 to 4 (K. Hanson, personal communication, December 16, 2013). Reviewing Equation 10, it is easy to see that by doubling the R-value, the amount of heating/cooling capacity required in a given environment is cut in half. Reducing the heating/cooling requirements has multiple upstream benefits: first, half of the HVAC units could be taken out of theater (or never deployed at all); second, removing half of the HVAC electrical load (~5.7MW) means that 56 100kW generators are unnecessary, which will save nearly 3,851,000 gallons of fuel per year; and third, by not having to deliver that fuel to FOBs the Marines will save a total of 30,800,000 gallons per year (Vavrin, 2010).

(2) Contribution of the ExFOB. The shelter liners are another program that benefitted from the ExFOB’s accelerated timeline. From their initial demo at ExFOB

2010-1 until their procurement in October 2010, there were only seven months from start to finish. By getting the liners purchased 15 months ahead of the typical COTS schedule, the ExFOB potentially saved the Marine Corps nearly 4.8 million gallons of fuel being used to cool FOB tents.

C. PHASE THREE: VALUE ANALYSIS

In this phase, the ExFOB is analyzed using KVA theory to answer the research question: Is the ExFOB value added to the USMC? KVA theory is generally used to assess whether steps in an organizational process add value or are wasteful to a product (Housel & Bell, 2001). These steps or points of analysis are value centers. For the purpose of this analysis, the value centers are used to assess value added by the ExFOB to acquisition processes.

This analysis uses ten value centers that were developed in the NPS thesis *Assessing the Value of the Joint Rapid Acquisition Cell* by Middleton (2006). The value centers were determined to be vital to rapid acquisition and the acquisition community (Middleton, 2006). Additionally, "without these centers, rapid initiatives … would not be successful in meeting the warfighters' immediate needs" (Middleton, 2006). The value centers contribute to a faster acquisition process when the knowledge is included into the acquisition community. Although the ExFOB is not an acquisition organization, the value centers can be used analogously because the ExFOB serves to accelerate the acquisition of expeditionary energy solutions for the USMC.

The value centers were slightly adjusted to fit the ExFOB more appropriately. The approach to this analysis is an objective view of each value center with no assumption of value. The value centers are further grouped into measuring the movement of a need through the acquisition process and methods used by the ExFOB. The last value center considers the ExFOB's suitability compared to other processes in solving future expeditionary energy requirements.

1. Speed

Speed is an essential part of acquisition depending on the situation. As seen in Phase One of the analysis, the rapid acquisition processes have fast duration times from identifying a need to fielding a solution. There is no set timeline for each process except for the REF as referenced in Figure 6. Most processes complete the task as quickly as possible.

The ExFOB does not have a set timeline for finding an expeditionary energy solution, but parts of the process are deliberate. The demonstration phase is designed to be one week, and the technology demonstration/engineering evaluation is about a month. The field evaluation phase, which is the most important, is not on a set timeline. This overall tempo does help to keep the process moving. Although the ExFOB is not trying to identify solutions immediately, it is important for the ExFOB to move fast. It must move fast because the USMC is on a timeline to meet certain energy requirements by years 2015, 2020, and ultimately 2025 (Figure 1). Also, technology is rapidly developing in the energy field so the faster a solution is selected and fielded, the more benefit to the USMC. Finally, the ExFOB can also be used to find UUNS solutions. UUNS by nature is supposed to meet an immediate need for the warfighter. As such, the ExFOB process can be tailored accordingly to meet those needs.

The speed of the ExFOB is valuable to the USMC and DOD because it identifies solutions faster than the traditional acquisition process. The speed of the RDT&E then leads to a faster fielding of the capability. And, again, the ability to find UUNS solutions makes the ExFOB extremely valuable to the current needs of the USMC and not just long-term needs.

The ExFOB not having a set timeline and having a semiannual schedule is not value added in the short term. For example, the ExFOB finding UUNS solutions does not provide the end users with a time frame in which a solution will be found. The REF conversely advertises a set time to find solutions. It finds energy solutions just as the ExFOB does and with what appears to be equal quality. The REF also does not have a set schedule to start a project. This incentivizes the movement to find a solution and provides

expectation to the warfighter. The ExFOB is only one step in the acquisition process so flexibility and goals for the short term will add value.

2. Budgetary Options

Funding drives everything in the DOD. As phase one highlighted, resourcing in the DOD is a very deliberate and lengthy process, mainly because the DOD is so large. The more funding available, the more the service or organization can do. Similarly, the more budgetary options available, the more the USMC as well as the ExFOB can do. The ExFOB has a baseline RDT&E budget as well as O&M budget.

The ExFOB appears to use funds from UUNS when finding an UUNS solution. This is value added because it allows the ExFOB to do more than what is planned using the baseline budgets. The REF is very similar in that it can handle UONS which comes with access to other funding. The more access the ExFOB has to funding, the faster it can help meet the USMC energy goals.

3. Streamlined Bureaucracy

Every large organization has a bureaucracy, and the DOD is no exception. Even at the USMC level, it exists, and it inherently slows down any process. The rapid acquisition processes were created to circumvent most of the bureaucracy to expedite capabilities to the warfighter. Similarly, the E2O was established to handle all USMC expeditionary energy matters.

The E2O and ExFOB process have added value to the DOD by streamlining how the USMC and the DOD approach energy issues. The ExFOB specifically streamlined how the USMC handles expeditionary energy solutions by leveraging industry and other sources. The non-value added aspect of E2O and ExFOB is that the bureaucracy is now larger.

4. Focus

Rapid acquisition in each service is handled by the regular acquisition staff. The only exception to this is the REF because it is a stand-alone organization within the Army

and resourced accordingly (Middleton, 2006). Consequently, the regular acquisition staff is taxed with the additional duties to meet urgent needs.

E2O and ExFOB process are value added because they are an established organization and process with one focus—expeditionary energy. Energy, in general, is a top priority for the DOD and is now an integral part of everything Marines do. The E2O is staffed to focus on this priority and shape future USMC capabilities through the ExFOB and other means.

5. Wider Portfolio Balance

All acquisition processes consist of three components: requirements, resourcing, and acquisition (Chyma, 2010). Each service has its own version of these components specifically designed to equip the service according to its required capabilities. In terms of requirements, if they are applicable to each service, then the JCIDS process is used. Since energy affects more than one service, the JCIDS process applies and has implications for all services. For example, many land-based energy requirements for the Army are the same as the USMC.

The ExFOB adds value by solving expeditionary energy requirements for more than just the USMC. The PORs for the USMC could be used by the Army if desired. The ICD is evidence of the joint process and serves as the basis of each ExFOB. There is good collaboration between the Army and USMC on expeditionary energy initiatives so duplication of efforts is minimized.

6. Alignment with Acquisition Strategy

Acquisition process changes in the last decade have made DOD acquisition more efficient. JCIDS was a direct result of these changes and led to DOD's top-down approach compared to the services' old bottom-up approach. The result is better collaboration as pointed out in the wider portfolio section.

E2O and the ExFOB were born out this new joint concept and ExFOB adds value because it aligns with acquisition strategy. Although it is at the USMC level, the ExFOB seeks to provide universal expeditionary energy solutions. USMC does not procure

solutions for other services but shares the information. This is particularly important in a fiscally-constrained environment. The ExFOB also leverages industries' knowledge by soliciting COTS products. This method saves DOD considerably in RDT&E costs and aligns with new acquisition initiatives of buying COTS—both adding value. There could be a tendency to find USMC-only solutions, which would be non-value added, since the ExFOB's primary goal is to meet the USMC expeditionary energy requirements.

7. Impartiality

As mentioned previously, acquisition at the USMC level always has the potential for service bias. This also applies across the board with rapid acquisition since these organizations are service-specific except for the Joint Rapid Acquisition Cell. E2O and the ExFOB are predisposed to this bias but are impartial when it comes to expeditionary energy.

The ExFOB potentially does not add value to joint solutions if it solicits purely USMC requirements. However, the requirements were determined through the JCIDS process with other services represented, so there was value at least in that part of the process. This value center is likely least important since other services have organizations fulfilling their specific needs but will add value with collaboration.

8. Life-Cycle Costs

Inherent in rapid acquisition solutions is the concern of long-term sustainability and life-cycle costs (Middleton, 2006). It is a concern because rapid solutions are funded for an immediate wartime need and not programmed using PPBE. This is appropriate because the need may only be for the short term and not required in the long term. The requirement at some point is evaluated in the JCIDS process to determine whether it should be programmed or cancelled. At this point, the life-cycle costs are considered.

The ExFOB is value added in this regard because the materiel solutions become programs of record. This is attributed to the ExFOB in conjunction with the traditional acquisition process of finding solutions and then handing them to MCSC to formalize the requirement through PPBE and DAS. In doing this, training and life-cycle costs are

budgeted. In the cases where the ExFOB in conjunction with UUNS is used for materiel solutions, the life-cycle costs are not a concern and not value added. Because the ExFOB uses a thorough RDT&E process, the materiel solution is deemed to be the best available to meet USMC expeditionary energy requirements and is program ready, regardless of the acquisition process. Therefore, life-cycle costs are easy to ascertain.

9. Feedback

Most rapid acquisition processes lack a good feedback mechanism from the end user. The only exception appears to be the REF because REF personnel go forward with the end users to evaluate the product's effectiveness (Middleton, 2006). Traditional acquisition does not have this problem because items are thoroughly tested prior to procurement.

The ExFOB is value added in this regard because it also conducts thorough RDT&E. During the field evaluation phase, the materiel solution is tested in a real-world environment and feedback is provided accordingly. Also in some instances, ExFOB personnel accompany the equipment as part of the testing process. The manufacturers make changes based on the feedback, which leads to a better capability and developed requirement.

10. Evolving Nature of War

The evolving nature of war considers the challenges faced by the future warfighter. The future fights are likely not large conventional wars, but the DOD has historically manned, trained, and equipped itself for such wars. The DOD in the future needs to be lighter, faster, and more agile. Commensurately, the acquisition processes must change to respond to the future needs. For example, the REF was created for this purpose, and even if only considering energy solutions, it rapidly serves the warfighter. Although many improvements have been made, there is more to be done.

E2O and the ExFOB are value added in this regard because ExFOB is a faster and non-traditional process. E2O and the ExFOB are also concerned with expeditionary energy solutions, which is truly the evolution of warfare. Of course, rapid acquisition

processes are also able to field solutions to the warfighter and are equally value added. The ExFOB is not value added in its deliberate, semi-annual process in that it does not provide as much flexibility even when fulfilling an UUNS.

D. SUMMARY

The ExFOB program has successfully reduced the acquisition timeline, averaging approximately one year from demonstration to POR (when fulfilling requests generated by UUNS). Because of the speed of their process and their ability to rapidly evaluate and field test emerging technologies, the ExFOB has saved the Marine Corps nearly 24,000 gallons of fuel per day.

The value centers serve to highlight vital areas in acquisition processes. The knowledge gained in these areas through this analysis ultimately contributes to faster acquisition processes when included into the acquisition community. There were many value-added aspects of the ExFOB and a few non value-added ones. Applying this knowledge will improve acquisition processes and enable the Marines to continue to improve their energy efficiency.

V. CONCLUSIONS AND RECOMMENDATIONS

A. CONCLUSIONS

This project examined the contribution of the ExFOB program toward the USMC goal of reducing expeditionary energy use by 50 percent by 2025. The approach used was that of a comparative analysis of the ExFOB process relative to other acquisition processes, both rapid acquisition and traditional acquisition processes used within the DOD in order to measure the effectiveness of the ExFOB process and products toward reducing energy use, and evaluate the ExFOB's value to the Marine Corps. Overall, this project assessed the ExFOB's contribution toward a 50 percent reduction in Marine Corps expeditionary energy consumption, by answering the following three questions:

1. What are the advantages and disadvantages of utilizing the ExFOB program within different acquisition processes?

2. What are the contributions of the ExFOB programs and process?

3. Is the ExFOB value added to the USMC?

The analysis of the ExFOB was performed in three phases. The first phase analyzed the ExFOB from a "big picture" perspective as part of a process and how it functioned within the acquisition process as a whole. This analysis looked broadly at requirements, resourcing, and acquisition to answer the research question: What are the advantages and disadvantages of utilizing the ExFOB program within different acquisition processes?

The advantages of the ExFOB in requirements determination are twofold. First, with traditional acquisition, it accelerates the process with its streamlined RDT&E. The ExFOB takes the requirement from the ICD, selects a COTS solution, develops a requirement and re-inserts the requirement into the JCIDS process to be programmed faster than following the traditional process. Using UUNS, this entire process is much faster because requirements determination before the ExFOB is expedited. Additionally, using UUNS, there is no immediate requirements review because JCIDS and PPBE are

bypassed until a later review. The ExFOB requirements development process, however, is exactly the same.

The disadvantages of the ExFOB in requirements determination deals mostly with the ExFOB process itself. The process is chartered for semiannual events, which makes it less flexible. Although this is aligned with a long-term view of meeting USMC energy goals, flexibility may be needed to speed up the process or meet emerging requirements. Additionally, the ExFOB process seems to be set in time duration regardless of the urgency of the need. Compared to other acquisition organizations, not accelerating the ExFOB process and providing a time frame to find a materiel solution are disadvantages for the end user.

Advantages of resourcing for the ExFOB occur when using UUNS. Although this is not a direct function of the ExFOB, more funding allows for additional items to be tested during the ExFOB and faster acquisition once the ExFOB is complete. The ExFOB saves a significant amount of RDT&E funding and time by leveraging industry technology in COTS products.

Disadvantages of resourcing for the ExFOB are directly related to working in conjunction with traditional resourcing. The traditional resourcing provides a set amount of O&M and RDT&E funding. Finding expeditionary energy solutions at the ExFOB seems to be mainly limited by the amount of funding.

Advantages of acquisition for the ExFOB also relate to the process in which it works. Using UUNS, systems can be acquired by the USMC immediately following requirements development. This seems to be a key advantage since energy technology is rapidly changing and there is a trade-off between time to procure it and technology relevance. In general, the ExFOB as part of the traditional acquisition process makes the process faster over the aggregate.

A disadvantage of acquisition for the ExFOB is associated with the traditional acquisition process. Although ExFOB does increase the overall speed from identifying the need to fielding, the overall process is still much slower and time-intensive compared to rapid acquisition processes.

The advantages and disadvantages highlighted above mainly revolve around the purpose or intent of the energy need. The energy need may be short term or long term, so how the need is met is important. Expeditionary energy needs are an inextricable part of the USMC and a huge undertaking. The more flexibility and resources the E2O and the ExFOB have, the more successful they will be to meet any expeditionary energy needs.

The second phase quantified the contribution of the programs the ExFOB has evaluated and helped the USMC procure. Using MEB-A's 2010 fuel consumption in Afghanistan of 88,749 gallons per day as a baseline, the estimated fuel savings generated by four programs (GREENS, SPACES, LED Lights, and Shelter Liners) were calculated. By 2016, when SPACES reaches FOC, there will be the potential to save 23,651 gallons per day (8,632,716 gallons per year). Figure 24 shows combined fuel savings (in red) compared to the USMC long-term goal of a 50 percent reduction in expeditionary energy by 2025. So far there has been excellent progress in meeting the 2025 energy goal, and future capability improvements will continue to keep the USMC on track. It is important to note that this table assumes 100 percent utilization of new capabilities and discontinuing the use of the outdated equipment (i.e., when GREENS are installed at an FOB, the generator that used to provide that electricity must be shut down if not removed entirely).

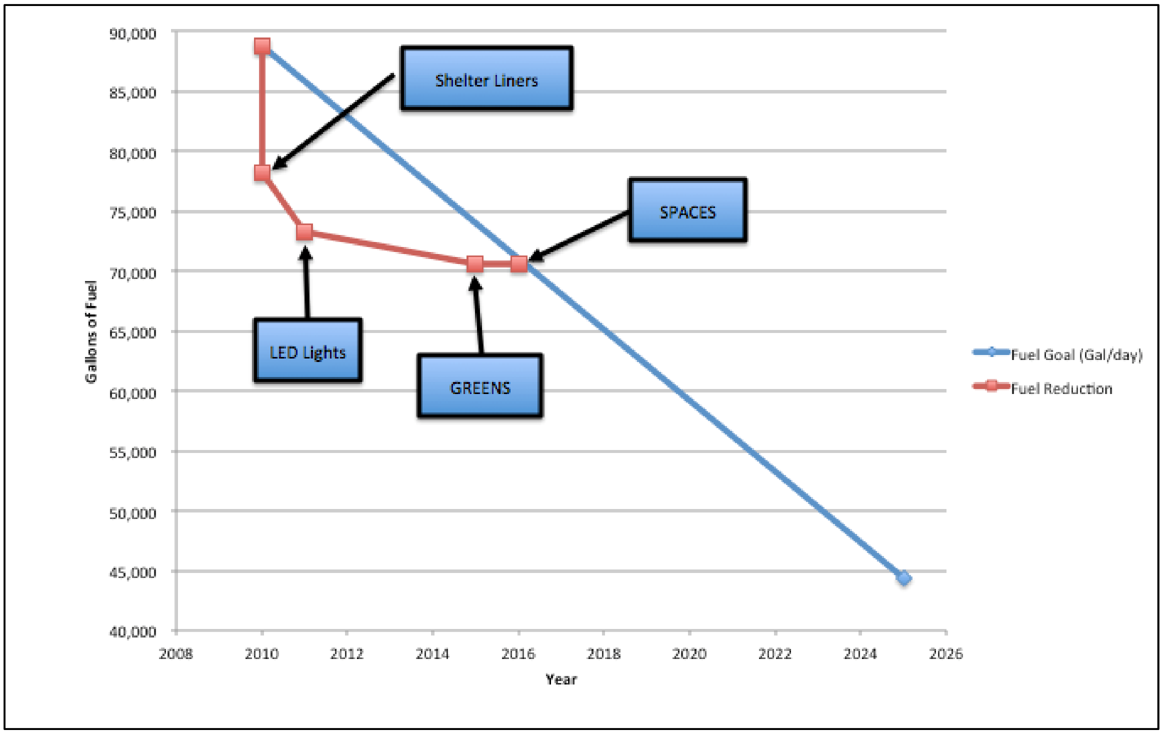


Figure 24. Progress Toward 2025 Expeditionary Energy Reduction

In addition to the fuel savings generated by new equipment, the amount of fuel saved by the expedited ExFOB process was also calculated. The annual fuel savings of each capability was compared with how quickly it was purchased via the ExFOB vice the traditional two-year COTS timeline and the time saved was translated into fuel saved on the battlefield. In total, because of the speed of their process, the ExFOB saved the Marine Corps more than 9.9 million gallons of fuel.

To date, several material solutions have been evaluated in the field, four of which have been transitioned to PORs and addressed at least eight of the E2W2 ICD capability gaps (K. Hanson, personal communication, December 16, 2013). We have shown that these four PORs could be expected to save millions of gallons of fuel per year. This fuel savings means that fewer vulnerable resupply convoys are needed. In addition to the outright fuel savings (and the associated monetary savings), less need for convoys translates directly to less risk to our national treasure, specifically USMC lives and equipment. The USMC proved the effectiveness of these PORs with a field test. In 2010, India Company, 3rd Battalion, 5th Marine Regiment utilized ExFOB technologies at

multiple bases and had 90 percent less fuel consumption (USMC E2O, 2013) than similarly-sized FOBs using standard equipment. This 90 percent reduction was achieved surprisingly quickly and demonstrates that the USMC can realistically achieve its desired expeditionary fuel goals in the timeline that has been put forth. Using the current technology provided by the ExFOB, the Marines have nearly reached the goal of an energy-independent FOB and are making good progress toward the 2025 goal.

The third phase was a value-added analysis. Using KVA theory, ten value centers were analyzed to answer the following research question: Is the ExFOB value added to the USMC? The value centers indicate that the ExFOB is a value-added process overall. There were more value added points than non-value added points. This is not to say the process is perfect and serves to highlight a number of improvement areas or best practices, which are included in the Recommendations section.

By accelerating the selection, test, and evaluation processes, the ExFOB has reduced the acquisition time of four energy-saving technologies, saving approximately one year off of the two-year COTS process. The fuel saved by the speed of the ExFOB process and the capabilities they have helped acquire have the potential to reduce expeditionary energy use by more than 26 percent by 2016 and keep the Marine Corps on track to meet its 2025 goal. These improvements to the acquisition process, timeline, and expeditionary capabilities of the USMC, coupled with the value added by the ExFOB program, demonstrate that is instrumental to helping the Marine Corps reduce their expeditionary energy consumption while improving their ability to conduct sustained operations from the sea.

B. RECOMMENDATIONS

The recommendations formulated here aim to serve to improve the ExFOB process based on the analysis and findings of this study. Although the benefit and added value of the ExFOB clearly outweigh its costs, some areas of improvement were highlighted particularly when comparing it to other processes.

1. Issue: Increasing the ExFOB Responsiveness to USMC Requirements

The ExFOB by design is a semi-annual venue to identify, evaluate, and accelerate material solutions to fulfill USMC expeditionary energy capability gaps (USMC HQ, 2012). This concept was born out of the USMC expeditionary energy strategy, which has a long-term view to meet these capability gaps and increase energy efficiency. The USMC strategy outlines expeditionary goals by years 2015, 2020, and 2025. From the analysis, the E2O and the ExFOB appear to be on pace to meet these requirements. However, some of the time gain in the process was the ExFOB being used in conjunction with UUNS in order to field material solutions rapidly. Since UUNS will not likely be part of the long-term plan, and the ExFOB aligned with the traditional acquisition process will be much slower, more flexibility in using the ExFOB is required. Conducting more ExFOBs, or possibly less, will allow the E2O flexibility to accelerate or slow down expeditionary energy materiel solutions based on meeting the energy goals as required. Also, if the ExFOB is periodically used in conjunction with UUNS, then an ExFOB can be immediately conducted to find a materiel solution, which is more aligned with the purpose of an UUNS.

a. Recommendation

Resource and change the ExFOB charter to allow more flexibility. The guidance can remain semiannual with a caveat of adjusting as required to meet emergent or long-term USMC needs. These changes will align better with long-term goals and ultimately increase ExFOB responsiveness to USMC requirements.

2. Issue: ExFOB Budget Only Provides Funding for Test and Evaluation

The ExFOB's four successful programs (GREENS, SPACES, Shelter Liners, and LED lights) have enabled the Marine Corps forces conducting expeditionary operations to save up to 8.6 million gallons of fuel every year. Additionally, because of the time saved by the ExFOB evaluation process, the Marines were able to save an additional 9.9 million gallons of fuel by quickly getting efficient technologies to the field. During wartime, the ExFOB was able to take advantage of the UUNS process and the (relatively)

ready access to funding. As the conflict in Afghanistan draws to a close and UUNS funding becomes less available, the ExFOB will need continued supplemental funding to enable them to continue to rapidly get new capabilities to the USMC fleet.

a. Recommendation

Establish a discretionary budget for the ExFOB to use to rapidly procure new capabilities and to quickly take advantage of the cycle of continuous improvements in terms of efficiency, cost, and performance. Like the UUNS process, capabilities that are purchased with this discretionary budget could then be subject to review using the UNS process and either adopted as a POR or discarded after their initial purchase.

3. Issue: ExFOB Faces a Race Against Rapid Technology Advancement

Energy technology is a massive growth industry due to many factors including energy security, climate change concerns, and desires and requirements to be off-the-grid. Further growth and capability of energy products is likely to continue. The ExFOB has demonstrated that in a short amount of time, with limited budget requirements they can assemble a FOB with 90 percent fuel reduction.

a. Recommendation

The ExFOB should look for short-term solutions to their long-term goals and focus on multiple means of attacking the energy problem. Conservation and decreasing demand through small innovations and technologies combined with improved technologies on the generation and storage side are a proven method to decrease fuel energy required in theater and increase USMC expeditionary capability. Any technology-related material solution the USMC chooses to invest heavily in may likely be overpriced or outdated by the time it reaches FOC. Examples of this can be seen in both the GREENS and SPACES systems: within two years of their IOC, each system had follow-on versions that offered more capability.

C. RECOMMENDATIONS FOR FURTHER STUDY

While conducting this project, we identified areas of potential further research. One area deals with the life cycle or longevity of energy products. Since energy solutions are rapidly improving, a cost-benefit analysis on the longevity of certain products (i.e., GREENS) or the replacement frequency would help the USMC to better estimate real life-cycle costs. It also provides a baseline for product longevity or usefulness.

Another area of study is an in-depth look at the ExFOB process compared to other comparable processes. Our analysis examined the ExFOB from a “big picture” perspective to see its effect on the overall acquisition process. This analysis would involve analyzing the phases of the ExFOB as compared to other processes to determine best practices or areas of inefficiency.

A third area for follow-on study is an investigation into what extent the USMC has changed its operating procedures take advantage of the capabilities provided by the ExFOB. The analysis would examine how widely the new capabilities have been distributed throughout the Marine Corps units, whether the standard procedure for establishing and operating FOBs has been changed to utilize GREENS/SPACES/Shelter Liners/LED Lights and other energy-efficient technologies and finally, whether the systems are providing measurable increases to expeditionary capability.

APPENDIX ENERGY PROGRAM DATA

The following data are from the REF "Edge to Energy" initiatives. Twelve initiatives commenced in 2012 and were completed at varying times throughout 2013. The data are summarized in Table 14.

Item	Req gen	Req received	Proj start date	Proj validation	Delivery	Days to Ship	Total time (days)
Net Zero Combat Outpost	77	Jun-12	Sep-12	90	Aug-13	330	497
Lite Camp JTF_B	77	Jun-12	Sep-12	90	Jul-13	300	467
Lite Camp OEF	77	Jun-12	Sep-12	90	Jul-13	300	467
Regenerator T-series	77	Jun-12	Sep-12	90	Apr-13	210	377
Regenerator FORGE	77	Jun-12	Sep-12	90	Apr-13	210	377
Solar Stik 380/400	77	Jun-12	Sep-12	90	Apr-13	210	377
Solar Stik WASP	77	Jun-12	Sep-12	90	Apr-13	210	377
MILSPRAY	77	Jun-12	Sep-12	90	Sep-13	365	532
INI FlexFuel	77	Jun-12	Sep-12	90	Apr-13	210	377
Qinetiq 1kW Genset	77	Jun-12	Sep-12	90	Apr-13	210	377
Qinetiq IWS	77	Jun-12	Sep-12	90	Jun-13	270	437
PM MEP TQGs	77	Jun-12	Sep-12	90	Apr-13	210	377
						210	377

Note: REF requirements generation data from (USD [AT&L], 2009, Figure 3) and all other data from (W. Garland, personal communication, January 29, 2014).

Table 14. Data Summary of REF "Energy to Edge" Initiatives

The following data are from the USMC ExFOB programs of record (POR). Four PORs commenced in March 2010 and were completed at various times. The data are summarized in Table 15.

Item	Proj start date	Proj validation	Days to Ship	Total time (days)
SPACES	Mar-10	90	270	360
GREENS	Mar-10	90	390	480
LED	Mar-10	90	270	360
Shelter	Mar-10	90	210	300
			270	360

Note: Data from (K. Hanson, personal communication, December 16, 2013).

Table 15. Data Summary of ExFOB PORs

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LIST OF REFERENCES

Baldauf, A., & Reherman, J. (2011). *Increasing responsiveness of the rapid acquisition process: The Army Rapid Equipping Force*(Master's thesis, Naval Postgraduate School). Retrieved from http://edocs.nps.edu/npspubs/scholarly/JAP/2011/June/11Jun_Baldauf_JAP_Final.pdf

Branch, E. B. (2012, May). *Department of the Navy acquisition and capabilities guidebook* (SECNAV M-5000.2). Washington, DC: Deputy Assistant Secretary of the Navy (Research, Development and Acquisition) Acquisition and Procurement.

Canaday, H. (2012, May). Portable power. Retrieved March 2014 http://www.kmimediagroup.com/special-operations-technology/articles/399-special-operations-technology/sotech-2012-volume-10-issue-3-may/5439-portable-power-sp-761

Chairman of the Joint Chiefs of Staff. (2012a, January 10). *Joint Capabilities Integration and Development System* (CJCSI 3170.01H). Retrieved from http://www.dtic.mil/cjcs_directives/cdata/unlimit/3170_01.pdf

Chairman of the Joint Chiefs of Staff. (2012b, January 19). *Manual for the operation of the Joint Capabilities Integration and Development System*. Retrieved from http://jitc.fhu.disa.mil/jitc_dri/pdfs/jcids_manual_19jan12.pdf

Chyma, T. D. (2010). *Rapid acquisition*. Retrieved from http://www.dtic.mil/get-tr-doc/pdf?AD=ADA544317

Department of Defense. (2013). *Defense acquisition guidebook*. Retrieved January 15, 2014 from https://acc.dau.mil/CommunityBrowser.aspx?id=654219

Exec. Order No. 13423, 3 C.F.R. 3919 (2007). Retrieved from http://www.gpo.gov/fdsys/pkg/FR-2007-01-26/pdf/07-374.pdf

Flynn, G. J. (2008, October 17). *The Marine Corps Urgent Needs Process (UNP) and the Urgent Universal Need Statement (Urgent UNS)* (Marine Corps Order 3900.17). Washington, DC: Headquarters United States Marine Corps, Office of the Deputy Commandant for Combat Development and Integration.

General Services Administration. (2014, April 14). SPACES MSD kit (complete). Retrieved April 14, 2014, from https://www.gsaadvantage.gov/advantage/catalog/product_detail.do?type=FOB&dir=asc&oid=630461753&contractNumber=GS-07F-0131N&itemNumber=848AKIT

Housel, T., & Bell, A. (2001). *Measuring and managing knowledge.* Boston, MA: McGraw-Hill/Irwin.

Iris Technology Corporation. (2010, June 1). *SPACES product brochure*. Retrieved from https://www.iristechnology.com/manuals/BR-Iris-SPACES.pdf

Jameson, LLC. (2014, April 11). EMI hardened LED stringable shelter light. Retrieved from http://www.jamesonllc.com/PDF/product_sheets/LED_Shelter_Lights.pdf

Kauchak, M. (2011). Green solutions for shelter systems: DoD is eyeing renewable energy sources and more efficient sub systems. Retrieved from http://nsrdec.natick.army.mil/media/print/GreenSolutionsforShelter.pdf

Kendall, F. (2013, November 25).*Operation of the defense acquisition system* (Interim DOD Instruction 5000.02). Washington, DC: Office of the Under Secretary of Defense for Acquisition, Technology, and Logistics.

Magnus, R. (2008, March 10). *Marine Corps Expeditionary Force Development System (EFDS)* (Marine Corps Order 3900.15B). Washington, DC: Headquarters United States Marine Corps, Office of the Assistant Commandant of the Marine Corps.

Marine Corps Systems Command. (2011). Generator set, diesel engine, 3 kW, 60Hz [Fact sheet]. Retrieved from http://www.marcorsyscom.marines.mil/ProgramManagementOffices/EPSHome/MobileElectricPower/MEPMTG3KW.aspx

Marine Corps Systems Command. (2011). *USMC acquisition initiatives in tactical electric powe*r [Presentation slides]. Retrieved from http://www.dtic.mil/ndia/2011power/GeneralSession_Gallagher.pdf

Marine Corps Systems Command. (2012, December 20). MCSC helps Marines go green [Press release]. Retrieved from http://www.marcorsyscom.marines.mil/News/tabid/5830/Article/136008/mcsc-helps-marines-go-green.aspx

Marine Corps Systems Command. (2014a). LED lighting. Retrieved from http://www.marcorsyscom.usmc.mil/sites/pdmcse/datasheets/shelters110800_LED%20Lights.pdf

Marine Corps Systems Command. (2014b). Radiant barrier liner. Retrieved from http://www.marcorsyscom.usmc.mil/sites/pdmcse/datasheets/shelters110800_Insulating%20Liners.pdf

Marine Corps Warfighting Lab. (2010, April 7). *Experimental Forward Operating Base (ExFOB), Power and Energy* [Presentation slides]. Retrieved from http://www.dtic.mil/ndia/2010MCSC/WednesdayLasswell.pdf

Martin, J. (2004, September). *Marine Corps Expeditionary Power Systems Solar Power* [Presentation slides]. Retrieved from http://proceedings.ndia.org/5670/Solar_Power-Martin.ppt

Middleton, M. (2006). *Assessing the value of the Joint Rapid Acquisition Cell* (Master's thesis, Naval Postgraduate School). Retrieved from http://www.dtic.mil/dtic/tr/fulltext/u2/a462660.pdf

Minstral. (2013). U.S. Department of Defense: Planning, programming, budgeting, execution [Presentation slides]. Retrieved from http://www.slideshare.net/tomlindblad/ppbe-tutorial-nov-2013

Naval Air Systems Command. (1986, October). Standard aircraft characteristics: AV-8B Harrier II. Retrieved from: http://www.history.navy.mil/planes/av-8b.pdf

Office of the Assistant Commandant of the Marine Corps. (2009, November 19). *Establishment of the Marine Corps Expeditionary Energy Office* [Memorandum]. Washington, DC: Author.

Office of Management and Budget. (1992, October 29). *Circular No. A-94 revised*. Retrieved from http://www.whitehouse.gov/omb/circulars_a094

Petraeus, D. (2010, January–February). Adaptive, responsive, and speedy acquisitions. *Defense AT&L*. Retrieved from http://www.dau.mil/pubscats/ATL%20Docs/Jan-Feb/petraeus_jan-feb10.pdf

PPBE process: Planning phase. (n.d.). Retrieved from http://www.acqnotes.com/Acquisitions/Planning.html

Ristinen, R. A., & Kraushaar, J. J. (2006). *Energy and the environment* (2nd ed.), Hoboken, NJ: John Wiley & Sons.

Taking alternative energy 'to the edge.' (2013). *The AMMTIAC WSTIAC Journal*, *2*(1). Retrieved from http://ammtiac.alionscience.com/pdf/AWJV2N1_ART04.pdf

Techshot Lighting, LLC. (2014, April 11). Shelter lighting system. Retrieved from http://www.techshotlighting.com/about.html

Tiron, R. (2009, October 16). $400 per gallon gas to drive debate over cost of war in Afghanistan. *The Hill*. Retrieved from http://thehill.com/homenews/administration/63407-400gallon-gas-another-cost-of-war-in-afghanistan-

UEC Electronics. (n.d.) Case study: GREENS. Retrieved from http://www.uec-electronics.com/documents/GREENS%20Case%20Study.pdf

UEC Electronics. (2012, July 24). Headline: UEC Electronics wins a new Marine Corps GREEN production contract. Retrieved from http://www.uec-electronics.com/about/news/UEC%20Electronics%20WINS%20new%20$40M%20GREEN%20Contract.pdf

UEC Electronics. (2013, December 31). Renewable energy on the rise in DoD. Retrieved from http://www.uec-electronics.com/about/news/GREENS%20Order%20Dec%202013.pdf

Under Secretary of Defense for Acquisition, Technology, & Logistics. (2009). Fulfillment of urgent operational needs. Retrieved from www.dtic.mil/ndia/2010psannualreview/TuesdayGansler.pdf

U.S. Army. (2010). *TRADOC generating force study* (TRADOC Pamphlet 525-8-1). Retrieved from http://www.tradoc.army.mil/tpubs/pams/tp525-8-1.pdf

U.S. Army Headquarters. (n.d.). *Overview brief: Army Asymmetric Warfare Office* [Presentation slides]. Washington, DC: Headquarters, Department of the Army, Office of the Deputy Chief of Staff.

U.S. Army Headquarters (2008). *General Engineering* (Field Manual 3-34.400). Washington, DC: Headquarter, Department of the Army. Retrieved from http://armypubs.army.mil/doctrine/DR_pubs/dr_a/pdf/fm3_34.pdf

U.S. Army Rapid Equipping Force. (n.d.-a). Home. Retrieved from http://www.ref.army.mil

U.S. Army Rapid Equipping Force. (n.d.-b). REF history. Retrieved from http://www.ref.army.mil/faqs.html

U.S. Army Rapid Equipping Force. (2009). REF process. Retrieved from http://www.ref.army.mil/aboutus.html#baaprocessline

U.S. Marine Corps Expeditionary Energy Office. (n.d.). Marine Corps Expeditionary Energy Office. Retrieved from http://www.hqmc.marines.mil/e2o/ExFOB.aspx

U.S. Marine Corps Expeditionary Energy Office. (2011, September). *USMC initial capabilities document for expeditionary energy, water, and waste*. Retrieved from http://www.hqmc.marines.mil/Portals/160/Docs/USMC%20E2W2%20ICD.pdf

U.S. Marine Corps Expeditionary Energy Office. (2013). Vision for the USMC Expeditionary Energy Office. Retrieved March 14, 2014, from http://nps.edu/Academics/OtherPrograms/Energy/docs/speakers_events/energy_seminar_130227_charette_presentation.pdf

U.S. Marine Corps Headquarters. (n.d.-a). ExFOB process. Retrieved from http://www.hqmc.marines.mil/e2o/ExFOB/ExFOBProcess.aspx

U.S. Marine Corps Headquarters. (n.d.-b). ExFOB process brief. Retrieved from http://www.hqmc.marines.mil/e2o/ExFOB.aspx

U.S. Marine Corps Headquarters. (2011). *United States Marine Corps expeditionary energy strategy and implementation plan*. Retrieved from http://www.hqmc.marines.mil/Portals/160/Docs/USMC%20Expeditionary%20Energy%20Strategy%20%20Implementation%20Planning%20Guidance.pdf

U.S. Marine Corps Headquarters. (2012, March). *Experimental forward operating base (ExFOB) charter*. Retrieved from http://www.hqmc.marines.mil/Portals/160/Docs/ExFOB%20Charter.pdf

Vavrin, J. (2010, June 16). Power and energy considerations at forward operating bases (FOB) [Presentation slides]. Retrieved from http://e2s2.ndia.org/pastmeetings/2010/tracks/Documents/9874.pdf

Willis, P. (2012). Joint Capabilities Integration and Development System (JCIDS) update [Presentation slides]. Retrieved from Defense Acquisition University website: www.dau.mil/MA/docs/JCIDS_Primer.pptx

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